JOURNAL

OF THE

# FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXXI. JANUARY, 1876. No. 1.

## EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors, the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

**Industrial Art.**—The universal enjoyment of beauty, in form and in color, whether exhibited in natural or artificial objects, and the changes of appreciation and increase of gratification, which proceed from custom, fashion, and habit, is a fact in human, if not also in animal nature, whose existence and influence must be admitted. Cleanliness, neatness and order, either in person, clothing or the commoner accessories of civilized life, form one standard of beauty, for the attainment of which half the lives of woman, if not of mankind, is devoted; and passing this lowest standard of luxury, every rank, station, or condition of life establishes and values some relative tastefulness in its belongings. The writer well remembers how the monotony of a long railroad journey was relieved from the continued perspective of frozen level fields, by the back view of two bonnets, made from dove colored silk, of artistic perfection and spot-

less beauty, with plaits in the most regular folds, enveloping the shape of the lovely coal scuttle, and with the radiant point of plaiting hidden by the neatest of minute bows. The geometrical considerations upon the lines of intersection indicated by the folds, were scarcely more abstruse and insolvable than the theological reflection suggested by the show of taste; and it is yet an undetermined question whether those particular bows were pomps or vanities, or a special dispensation. Even professed abnegation will not annihilate the fashion. When reduced to the elements of bare requirement, the Friends' male attire becomes something surprising. Given any article of necessity, comfort or luxury, no asceticism has ever overcome the love and desire for the beautiful; predominant always when necessity or comfort are equal, and frequently asserting themselves over either needs or desires.

With this existing and universal fact of demand, neither excellence nor cheapness of production warrants those who are engaged in industrial pursuits in neglecting the knowledge, or more properly the educated ability, of the artist. Whatever is made to be sold, especially must—regardless of the homeliness of purpose—have beauty of design or of color, together with good workmanship. All these qualities go to make up a value or price to the purchaser.

But it must not be assumed that because the desire for prettiness is pervading, and because there is an individuality in estimation or choice of handsome things, therefore taste is a matter of fashion, style or caprice; that either general demand by the most votes, or the personal opinion of one individual will suffice to make handsome things. Capability to design, either in line or color, comes to no one as Dogberry has it "by nature;" nor does individual or national appreciation of beauty become elevated, much less perfect, except after study, or at least familiarity with good examples. Owen Jones calls his book the "Grammar of Ornament" and there is a great propriety in the name. The laws of design are as definite as those of language, with much the same questions as to order, relationship, construction or elegance; differing for dissimilar styles as for divers tongues. The pupil in design has similar obstacles to encounter with those of the schoolboy in his alphabet and grammar; the ability to use the pencil or the brush will no more produce an artist, than the acquirement of the writing master's art, combined with all of Murray's rules, will make a poet; and a parallel kind of education to that which supplies admirers for the picture, gives readers for the poem.

A style of architecture or of line or color decoration may be appropriated and accompanied with incongruous details or effects, and the result may be striking, admired or fashionable, but with examination or time will depart the gratification of first view and a simple feeling of ugliness will follow.

Except that the principles of ornament have been read about and investigated far enough to discern, few people, only those with artist eyes—eyes which but rarely are found in northern European nations or their descendants—can recognize the fitting nature of each ornament to its style, and how painful to the unlearned, as well as to the learned, are departures from rules. This condition of taste can be well exemplified in any dry goods shop, by looking over a collection of old prints and seeing how some of them seem uncouth in line, irregular and unsatisfactory in color, while others of the same type and fashion produce at once an impression of suitability, elegance and beauty. One remarks that nobody would wear such a pattern to-day, but it is very pretty, or showy, or effective! Why these characteristics attach to some of the patterns and not to others, the educated artist can at once detect. Not that everything which is handsome is in style to sell, but that that which is in style and is handsome will sell best. Every maker or seller of jewelry or ornaments, carpet, or hangings, of prints or laces, finds some patterns which sell with great regularity, while others which may sell rapidly at first, quickly lose all demand; and most accomplished salesmen can select with certainty what will probably sell, after novelty has passed away.

The writer has a considerable collection of fashion plates for the present century, and interspersed with them are "fancy dresses" of corresponding dates. Remarkably, not singularly, the fancy dresses of 1800–10, 1810–20, 1820–30, 1830–40, 1840–50, and so on, *are all alike*, however dissimilar the style of dresses which varied from skirts three-quarters of a yard to those of six yards in circumference, within those dates. The *elegance* of all these costumes was found in their approximation towards the fancy styles at any time. This example is strictly not quite applicable to the question of educated taste now under consideration, but the analogy is a correct one.

The attempt to combine beauties by appropriation of an ornament here, a decorative line there, the copy of red roses from one pattern upon the beautiful pearl ground of another, is a feature of English

and of American industrial art; very cheap, very unintelligent, very inartistic, and it is gratifying to add, very unprofitable. The purchaser says there is an "I don't know what" about it, but she buys a French print or a piece of French jewelry when the English, German or American fabric is much more durable and intrinsically valuable, and is in so far better educated in art than the Germanic or native maker or seller.

The education of the buyer in art is one of comparison, not one of reasonable ground for estimation, but however attained, this education has now reached an eminence far above our native capability to supply. A person does not stop to estimate the strength of the bridge which carries him over the stream. No one who has a rational enjoyment in his dinner, desires to know much of the mysteries of the kitchen; outside of mechanics' lectures and useful-information periodicals, (which are imagined to have listeners or readers), the knowledge of an art is as great a bore as the enjoyment of its results is a pleasure. As in letters and as in music, so in art: the public taste becomes elevated by examples rather than by reasoning. The competition of examples is raising the standard in all regards.

Take, for instance, the painter's art. The competition of the photograph has given us a standard of correct drawing, shadow, and perspective, previously unknown. Forty years ago it sufficed to sketch a background, and the eye was demanded to tolerate errors of fore-shortening by the best of painters. To-day, no leniency can be admitted in these regards. The competition of the chromograph has already softened incongruous tints, and compelled the use of permanent colors of high natural tones. It is not supposed that either the photograph or the chromograph will take the place of the painting, but it is certain hereafter, that the painting must be superior in finish, in excellence, and in effectiveness to them.

In industrial art there are no photographs possible. The only mechanical additions to the art of design have been the engine lathe and the kaleidoscope. The use of the former has been fully availed of in its limited direction, but the arabesques of the latter in line and in color are yet to be made use of in many applications.

The field of industrial art is of great extent and comprehension; the line between it and architecture is very imperfectly marked; furniture, wall decoration, carpentering, carving, etc., are adjuncts to the architect's work in churches, halls or houses. In such

branches—for industrial art must divide into branches, both in study and in practice—a knowledge by no means incomplete, of the corresponding art must be attained by the artist. But by far the most difficult and important study of industrial art, after the acquisition of the laws and rules of decoration, is the capability of the material to be treated, and the utilizing of the methods of decoration at command.

Take the well known examples of method. The sand-blast which promised so beautiful results five years since, yet lingers comparatively unproductive; and mechanical wood carving has so far failed in effective or really tasteful work, while all artists admit the difficulties in both cases to lie in the want of designs, not in the method.

Unquestionably, many persons who have noticed the proposal to establish a school of design in Philadelphia, have looked upon the plan as kind of easy amateur procedure; that a few lessons in handicraft would allow the student to compete for a prize, and qualify him or her to decorate, or at least design a decoration, in some style, either florid or severe; but such persons or their friends will learn with dismay, that given the highest of talent, years of study and pursuit alone can attain eminence, and that few will ever reach mediocrity. All that education can do is to teach. Application, readiness, invention, DESIGN, can only come to the educated mind and skillful hand, and the natural gift of art ability.

If this city—if the nation—is to secure and maintain its eminence as a manufacturing one, it must do it through its ability, not through its machinery, handicraft, or its cheapness of production. In some branches of workmanship the mechanical excellence and inventive superiority will keep the business in the hands of our mechanics, but even here the coupling with taste, both in form and color, will prove advantageous; but in the textile fabrics, the furniture and jewelry, only original designs, not borrowed, not misunderstood or misappropriated, will preserve the tradesman and the workman from the local competition of every country town. The competition of unskilled labor is always destructive.

The success of a School of Industrial Art rests upon the same basis as the success of schools in other branches of learning. First of all, upon the value which the Community shall set upon knowledge acquired; what pre-eminence, distinction, or reward shall be attached to the acquisitions of the student. Secondly, the Students; under

the stimulus of elevated aims and hopes, the standard of selection of students can be brought to a high point, in mental, educational and natural artistic ability, and the efforts and labors of students will have corresponding energy. Lastly, the Tutor; although the before-named conditions are the more essential, and although with a mere schoolmaster, the school may thrive, yet eminence in all things is individual, and attainments of the highest order, with capacity to impart them, must be sought and secured to fill the place.

It would almost seem proper that the school be made one of the branches of technical education, which are now being grouped in one general head by the University of Pennsylvania at West Philadelphia, as has been done at Boston in Massachusetts Institute of Technology, where an industrial art class has already attained high prominence; but this suggestion may not be open to consideration until after the school shall have secured its independent support, which we think is the case at Boston. As remarked before in this paper, the kindred arts of mechanics and architecture are associated intimately in processes and results, and it would appear that with these studies, industrial art should also be associated.

---

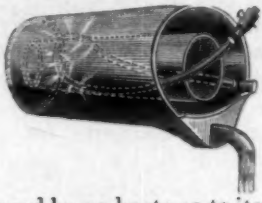
**Announcement of Lectures** to be given before the Franklin Institute at their Hall, commencing Tuesday, January 4th, 1876:

| | |
|---|---|
| One Lecture by Dr. C. B. Dudley, January 4th. | on Artificial Ice, |
| Three Lectures by Mr. Robt. Briggs, January 6th, 13th, 20th. | on Steam Boilers, |
| Two Lectures by Prof. E. D. Cope, January 11th, 18th. | on Paleontology, |
| One Lecture by Mr. Jos. Zentmayer, January 25th. | on Lenses, |
| Five Lectures by Prof. P. E. Chase, February 1st, 8th, 15th, 22d, 29th. | on Natural Physics, |
| Two Lectures by Prof. Persifor Frazer, February 10th, 17th. | on Geology, |
| One Lecture by Prof. M. B. Snyder, March 2d. | on Stellar Spectroscopy, |
| Two Lectures by Prof. L. M. Houpt, March 14th, 21st. | on Tunneling, |
| Two Lectures by Prof. R. E. Rogers, March 16th, 23d. | on Chemical Force. |

# BLAST-FURNACE TUYERES.

FRANCIS H. LLOYD.*

SIR:—My attention has been called to the remarks on "The working of Blast-Furnaces," with reference to the recent tuyere accident, in the *Journal* of Sept. 25. Your correspondent's challenge to iron-masters, who believe they have overcome the difficulty and danger arising from tuyere explosions, to make their success widely known, leads me to address you on the subject. I claim to have completely overcome the difficulty by doing away altogether with water jacketed or coiled tuyeres, and substituting a tuyere casing of about the same dimensions as the tuyeres in general use, but open at the outer end, and containing between the walls of the tuyere casing a spray pipe, throwing a sufficient supply of spray or small jets of water on the rear end and sides of the tuyere to prevent it from overheating or burning. More than 50 of these tuyeres are now in use with uniformly satisfactory results; they are more durable than other tuyeres, and are entirely free from risk of explosion. If through long wear or deficient water supply a tuyere should become defective, there need be no haste as to its removal, as no immediate harm can arise; any defect is at once apparent from the open end of the tuyere. We have now had these tuyeres in constant use at one furnace since last November, and since February last we have adopted them exclusively at two furnaces; they are now being adopted at a considerable number of furnaces elsewhere, and at three furnaces, besides those with which I am connected at Darlaston Green, they have been in use for many months. Many furnace managers have seen them at the Darlaston Green furnaces, and no one has ever doubted their safety, nor has any one who has tried them found them inefficient in any particular. The furnace keepers have far less work than where other tuyeres are in use, and are perfectly free from danger; besides this, the saving in actual cost of renewal of tuyeres we have found to be an important item, and the extremely rare occurrence of a stoppage for tuyering a still more important one. I shall have much pleasure in showing the



* From the *Mining Journal*, London, October, 1875.

tuyeres in use to any of your readers who are interested in the matter; and I trust ironmasters will no longer be open to the reproach made in the remarks in the *Journal*, that we "are compelled to sit down under a sense of an inability to help ourselves in such a matter."

*Wood Green, Wednesbury, Oct.* 13.

**A Non-Retreating Bunsen Burner.**—The low pressure of gas which prevails during the daytime in many places causes not a little inconvenience in the use of Bunsen burners of the usual form, as these are liable under such conditions to retreat when moved slightly, or when exposed even to such moderate currents of air as are produced by the motion of a person walking past them.

To obviate this inconvenience, which he had experienced in his own laboratory, President Morton, of Hoboken, has devised a burner which seems to meet the difficulty in a simple but scientific manner.

Considering that the retreat of ordinary burners was occasioned by irregularities of the nature of eddies in the flow of the ascending explosive mixture, by which its rate of ascent was reduced locally below that at which such mixture would burn downwards, he draws in the upper end of the main tube so that the mixed gases escape through what may be regarded as an aperture in a thin plate.

This presents, as is well known, the conditions requisite for a smooth vein, in the case of liquids, and inferentially in that of gases.

In fact, the burners so made have proved very satisfactory in actual use. The large burners will work under very low pressures, and smaller ones may be burned down until actually extinguished without any adjustment of air supply, and yet without possibility of retreating.

**Medal from the U. S. Government to Prof. Henry Draper, of New York.**—The very valuable assistance rendered to the Commission upon the Observation of the Transit of Venus, has been recognized by the presentation of a gold medal in testimony thereof.

The obverse of the medal has a figure of the heliostat employed by Doctor Draper in his preparatory labors with the photographers in practice; and the inscription, FAMAM EXTENDERE FACTIS HOC VIRTUTIS OPUS EST, ("To extend fame by deeds is a work of virtue."—*Virgil*); and the reverse is inscribed VENERIS IN SOLE SPECTANDÆ CURATORES R. P. F. S. HENRICO DRAPER, M. D., DEC. VIII, MDCCCLXXIV, ("The Transit of Venus Commission of the United States to Henry Draper, M. D., December 8th, 1874,") with a circle inscription around the edge, VIRTUS VIRTUTI ADDIT AVITO, (he adds luster to ancestral merit). Such public recognition of eminent worth or accomplishment has been rare by our government, and in this instance, particularly scientific men in our own country and in other lands will be gratified by its appropriate presentation.

# Franklin Institute.

HALL OF THE INSTITUTE, Dec. 15, 1875.

The stated meeting was called to order at 8 o'clock P.M., the President, Dr. R. E. Rogers, in the chair.

There were 110 members present.

The minutes of the last stated meeting, held November 17th, ult., were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library:

On the Dynamical Law of Horse-power of Steam Boilers, by John W. Nystrom, C. E., Philadelphia, 1875. From the author.

Twenty-third Annual Report to the Council of the City of Manchester, on the working of the Public Free Libraries, 1874–75. From Manchester City Councils.

The Actuary also reported that the Committee on Science and the Arts have recommended the award of the Elliott Cresson Gold Medal to W. G. A. Bonwill for improvements in his Electro-Magnetic Mallet for dental purposes, and the award of the Scott Legacy Premium and Medal to C. Tyson for his machine for uniting the soles to boots and shoes, which recommendations were received, ordered to lie over one month, and be reported to this meeting of the Institute.

Also, that a letter from H. Dumont Wagner to the Board, requesting them to elect a trustee to the Pennsylvania Museum and School of Industrial Art, was referred to this meeting.

The special committee appointed to co-operate with other bodies with the view of establishing an Industrial Art Museum, presented their report, which was read, and on motion of Prof. Houston was approved, and the committee discharged.

Mr. Hector Orr read the paper announced for the evening on "Atmospheric Electricity," its production and diffusion.

The Secretary presented R. E. Nichols' iron "Permanent Way for Railways;" H. Wrigley's automatic apparatus for working pumps on shipboard; Milford's patent sash holder and lock; Buck's bung faucet; W. G. A. Bonwill's electro-magnetic mallet for dental purposes, and Geo. Iles' differential compass.

The Meteorological Section presented its report which was ordered filed.

A report from the Committee on Science and the Arts, in relation to high pressure steam allowed by law on Western Rivers, embodying the following communication, to be signed by the officers and members of the Institute, and sent to both houses of Congress, was read, and on motion of Mr. Orr was adopted:

"HALL OF THE FRANKLIN INSTITUTE,

"Philadelphia, Dec. 15th, 1875.

"To the Honorable, the Senate and House of Representatives of the United States:

"The undersigned, members of the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, held at Philadelphia, in the State of Pennsylvania, respectfully represent that their attention has been directed to an amendment of an Act of Congress, entitled "an Act to provide for the better security of life on vessels propelled in whole or in part by steam," which amendment was approved December 17th, 1872, and which amended Act permits the use of an increased steam pressure in steam boilers of a certain class.

"By their Committee of Science and the Arts, they have examined the subject, and are of the opinion that the said increase of steam pressure allowed by the said amended Act, is not only improper, but prejudicial to the purpose for which the Act was originally enacted.

"At the request of a former Secretary of the Treasury, this Institute made a series of experiments for the purpose of determining the limits of safety, and means of preventing accidents in steam boilers, and made reports and suggestions upon those subjects, with a draft of a bill for the purposes of protection against accidents from steam boilers, which reports were accepted by the Secretary of the Treasury, and suggestions incorporated in various Acts approved by Congress.

"The said reports are likewise referred to as good authority, upon the subject of the strength of materials to be used for steam boilers, both in this country and in Europe, and the results and opinion expressed have been confirmed by the experience of British and French Scientists, and Government Commissions. We find that the increased pressure permitted by the amended Act of December 17th, 1872, will in many instances prove productive of accident, as permitting the use of steam pressures beyond the limits of safety, and we therefore respectfully recommend that so much of the Act referred to as permits of this increase of steam pressure be rescinded, and that a re-enactment be made, which shall restore the law as it stood before it was amended."

Prof. Houston moved that the meeting do now proceed to the election of a trustee to the Pennsylvania Museum and School of Indus-

trial Art as provided for in its plan of organization, and as communicated by letter from H. Dumont Wagner, Secretary, to the Board of Managers, and after considerable discussion, the motion was carried.

Mr. Durfee nominated the Secretary of the Institute to be *ex-officio* the trustee, and Prof. Houston nominated Mr. J. E. Mitchell. While the ballot was being taken Mr. Mitchell declined, and Prof. Houston moved that J. B. Knight be declared elected, whereupon, on motion of Mr. Hall, the motion to go into the election was reconsidered, and the further consideration of the subject of electing a trustee was postponed to the next stated meeting.

The President announced that in accordance with Section 7 of Article 14 of the By-Laws, the following nominations should be made at this meeting:

A President, Secretary, and Treasurer to serve one year; one Vice-President, eight Managers, and one Auditor to serve three years. The following members were then placed in nomination to be voted at the next annual election.

*For President*, R. E. Rogers, M.D.

*For Vice-President*, Henry G. Morris, J. E. Mitchell, Chas. Bullock (declined), and H. Cartwright (declined).

**For Secretary*, J. B. Knight and Wm. H, Wahl, Ph. D.

*For Treasurer*, Fred'k Fraley.

**For Managers to serve three years*, C. M. Cresson, Chas. H. Banes, Hector Orr, W. H. Wahl, Wm. Sellers, W. J. Budd, Robt. Briggs, J. W. Nystrom, Thos. Shaw, Sterling Bonsall, H. R. Hoyt, W. B. Bement, L. M. Houpt, J. Vaughan Merrick, H. Cartwright, C. Chebot, Richard McCambridge, H. W. Bartol, Wm. Adamson, J. E. Hoover (declined), Jas. Hunter, Geo. H. Hall, Cyrus Chambers, Jr., G. Morgan Eldridge.

*For Auditor*, Sam'l Mason.

The President appointed the following members to act as tellers at the annual election to be held January 19th, 1876:

Wm. A. Rolin, W. L. Dubois, Sam'l Sartain, W. Barnett LeVan, Wm. Taggart, John Canby, Geo. Gordon.

Mr. J. J. Weaver presented a series of resolutions addressed to the Board of Managers urging certain action on their part, looking to greater usefulness of the Institute, which was adopted.

On motion, the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

* The following have since declined: Wm. H. Wahl, Ph. D., for Secretary; W. B. Bement and L. M. Houpt, for Managers.

**Brief Note of Remarks on a Form of Pseudo Perspective for Illustration of Mechanical Objects.**—Made by Robert Briggs, at the meeting of the Institute, September 15th, 1875.

The advertising of machinery, engines, tools and apparatus, has led to the publication of numerous pictorial price lists, circulars and hand-books, having as a necessary accompaniment, illustrations to which the text refers. It is highly desirable, that these illustrations should exhibit the general appearance and the general proportions of the objects to be advertised, frequently requisite to draw them in groups or classes, and often essential that they shall be drawn to some relative, if not absolutely to uniform scale. The larger and more comprehensive machines or engines should also be shown from such point of view as will convey to the mechanic or engineer (purchaser or user) an idea at once of the arrangement, and of the proportion of the several parts of which the machines or engines are composed.

A mere drawing from an artist's *vue d'œil* is *such* a verisimilitude as will be tolerated by no practical man. A photograph, as ordinarily taken with a short focus (and often cat-a cornered), which can (if printed as a single card view) be reduced to perspective by holding to the eye, at some exact plane distance, may, from necessity, serve its purpose when isolated and examined alone. Such photographs, or engravings made from them, are very unsatisfactory for book illustration, not only from non-conformity of the plane distance with the proper book-reading one, but from the unsuitability of the plane distances with each other, together with dissimilarity of vanishing points and differences of angle of view. Many of the objections here stated attend pictures not made by the camera.

These considerations are sufficiently familiar to the intelligent engraver, and need only statement to him, but there are many other persons, more or less accustomed to books and pictures, who cannot have appreciated the bearing of these remarks upon the general illustrations daily observed by them. It is perhaps not saying too much, when the assertion is made, that most engravings are *not* seen or looked at as pictures in perspective, and that many people never see a picture as a scene, or endeavor to do so. Their eyes have become accommodated to a conventional representation, as really in false perspective as a Chinese drawing appears to be. Education has merely accustomed them to an arbitrary system of lines in which distance is imagined by reduction of size, and a picture *seems* to be correct, regardless of the ratio of the reduction. The Chinese perspective, without reduction, only fails in comparison to a miniature picture with an excessive angle of vision, by the admission of the existence of one correct point of view for the latter, although this point of view sometimes is chosen at less than eight inches from the eye.

To see a picture properly, the plane of the picture which is looked at *must* be at right angles to the line from the eye to the vanishing point, and the eye must be exactly so far removed from the picture as to give the real effect of relief and distance.

The angle of vision of a lens is much greater than that of the eye, and although some advantage is afforded in taking pictures by a camera, especially interior or street views, whereby the larger part of a room or an entire facade can be depicted on one plate, it must not be overlooked, that such views are purely arbitrary, and from no possible point of sight can they be correct. This defect of the lens becomes painfully apparent when a photograph of a large machine, erected in a small room, is assayed, and it is (so far as our eyes are accustomed to picture) aggravated when the object is so large that the camera has, so to speak, to look up at it.

The *civilized* perspective is the transcript of intercepted rays on a *vertical* plane, and the deviation of the plane from the vertical, which occurs when the negative plate is deviated, although in strict accordance with the perspective, and although if the place of the eye viewing the plate is made relatively that of the camera which took the picture, the visual difficulty disappears; yet the error of deviation of view condemns such a picture altogether.

These facts in perspective can be readily seen by examination of a set of photographs from nature, and can be made conspicuous to an audience by a lantern, as was done by several views at the meeting.

For the purpose of mechanical illustration, it is requisite that the details should be not merely sketched vaguely, but distinctly shown with draughtsmen's or photographic accuracy. No background or distance is desired, and the object should be isolated. Most objects have a front which it is desirable to exhibit. When some one front will not suffice to show all that is wished, two or more views looking at the machine at the sides or ends, are called for. The direct plane views fail to give any relief to projecting parts, even if deep shadows are thrown down, and it follows, consequently, that the object should be taken at a slight angle with the line of front. This angle had best not be excessive; the front should predominate, and the retreating end should only give depth and projection to the outline.

Heavy sunlight shadows should not be made in any case; the lines of shadows are confusing. Shades should be distinct, but subdued and dark lining is necessary for effect. The distant (or back) objects or lines should never be shaded or obscured, nor should the distance itself be shaded back, but the lines be lighter—*more distinct*—ending in the more remote parts in pure outline, unshaded and fine lined. It is to be noticed, that there being no background, the distance should die into the white of the paper.

These remarks apply as well to engravings with correct perspective as to those drawn as hereafter described, and the system of line drawing applies equally to mechanical and architectural drawings. Elevation, Plan, Section, etc.

In *drawings*, great effect and clearness is imparted by using black ink and broad dark lines for the front parts, clear black lines, but thinner and less pronounced for the parts behind, omitting all dark

lining on outlines further back, and by using very faint ink (still getting perfect lines) for objects behind the machine, or for distant walls. [For exhibition to the public, shaded architectural drawings are admissible, but for practical work in architecture and mechanics, a shade or shadow on a drawing is an evidence of idleness, if not incompetency.]

As a general rule, the objects to be depicted should be twisted to an angle of 9° to 10° (that is, the person, or camera viewing them should stand so that a given *depth* of side will appear on the perspective plane about one-sixth as long as the same dimension on the front view), and photographs or sketches from objects thus *posed*, if taken from long distances, so that the angle of vision for the entire figure shall be small, can be used singly or in groups on a page with much satisfaction.

If a group of articles of similar character are to be shown, it is very much better that the same point of view shall be taken for them so that the comparison, each with the other, can the more readily and positively be made.

This consideration leads away from a true perspective at once, and points to a mere projection. And it will be found that a plane projection at the angle designated, will differ so little from a true perspective for miniature views as generally looked at as to deceive any but a critical observer. In such projections it will be found advisable to consider the plane of vision above the object in the same position as was assumed at the side of it.

The kind of isometrical drawing thus obtained, differs from that usually practiced by the reduction of the proportion of side and top dimensions to those of the face, but the result of this reduction is to remove much of the obvious distorted effect. The system cannot be recommended either for large objects or for large views, and should be confined to miniature representations. Still in miniature representations of objects of considerable magnitude it can be adopted with success.

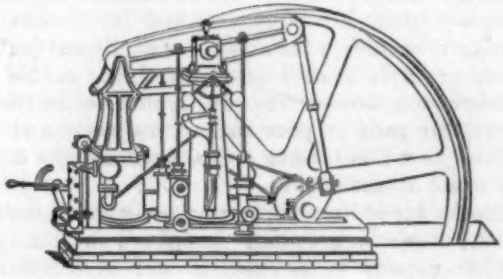


Fig. 1.

Figure 1 shows an outline sketch of an engine machine directly

from a working drawing to scale. This sketch is such as is required by the engraver on the block of wood before engraving and shading.

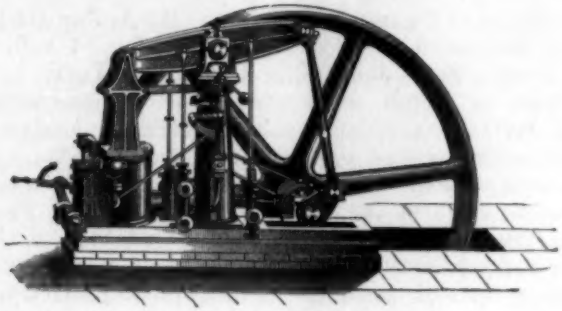


Fig. 2.

Figure 2 shows a finished woodcut from the same sketch, and can be pronounced satisfactory from either the pictorial or mechanical standpoint.

The sketch Fig. 1 was made in less than $2\frac{1}{2}$ hours time from a working drawing, which showed a front elevation, two end views, and a plan, all drawn to the scale of $1\frac{1}{2}$ inches to the foot, or one-eighth full size. The front dimensions were all taken by a pair of proportional compasses, set at one to six, and the end and top dimensions by reducing one to six *twice over*. The scale of the figure is consequently one forty-eighth on the front, and one two-hundred-and-eighty-eighth at the end and top. Of course all the lines in horizontal planes at right angles to the front (in the machine itself, or its working drawing), are inclined 45° to the horizontal or vertical lines in the face of the Fig. 1, and any length measured on those diagonal lines is a little more than *one-fourth* the front scale, (the true scale of end or top dimensions consequently becomes one two-hundred-and-fourth part in place of one two-hundred-and-eighty-eighth.)

The example chosen to illustrate here is purposely that of a large object, the natural size being over 8 feet high by 15 feet long. If the style of drawing suffices for such a picture, and without painful distortion, and the scale is practically preserved, it is apparent that for smaller objects its suitability is demonstrated.

The system was introduced in illustrating a catalogue nearly fourteen years since, the writer supplying the outline drawings for several sheets of objects, and the artist who completed them has since adopted the same style with much success. And from the facility it affords for making a scale picture from a set of bare working drawings, it is thought it merits publication at this time.

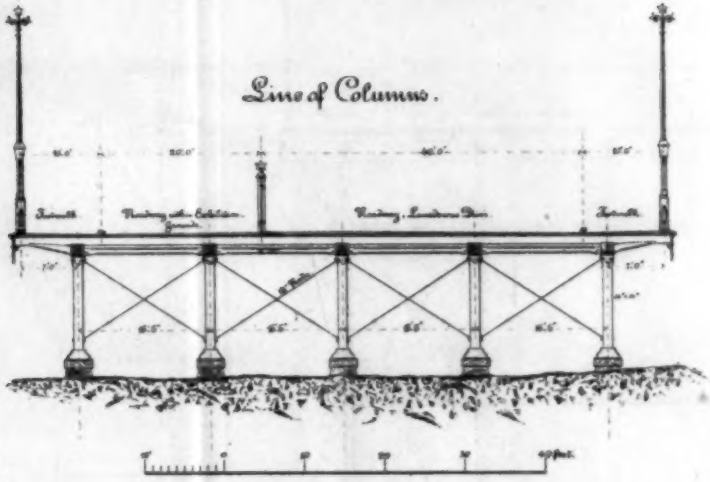
# Bibliographical Notice.

THE ELEMENTS OF GRAPHICAL STATICS. By A. Jay Du Bois, Prof. C. & M. Engineering, Lehigh University, Pa. 1 vol., Text and Atlas, 2 vols., 8vo. John Wiley & Son, New York.

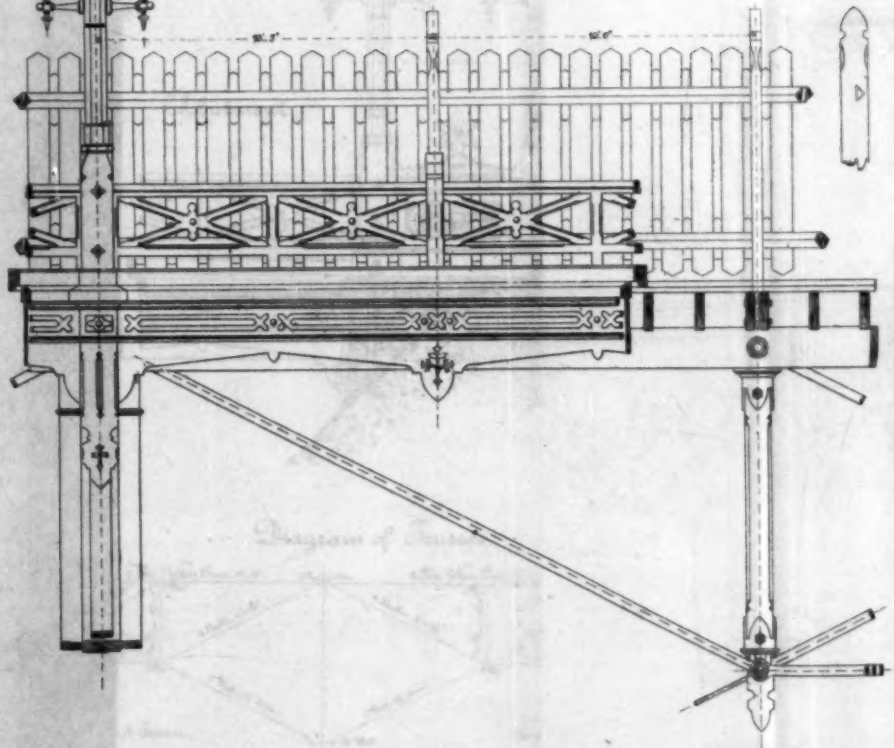
This work is a full university course of instruction in the graphical method, combined with algebraical analyses of applied mechanics, applied to structures of all kinds; from which the advanced student will have derived such instruction as will be of extreme value in the practice of engineering. The grouping of all the separate examples of graphical methods of the French geometers and mathematicians of the past half century, the application of some isolated problems of descriptive geometry, and the forming of a separate branch of study has been well effected with German thoroughness, and is attributed, in the translated introduction by Dr. J. J. Weyrauch, of Stuttgard, to Prof. K. Culmann, of Zurich. The introduction of Doctor Weyrauch possesses the highest value as a historical sketch, although somewhat partisan in its nationality. It follows the course of one branch of mathematical inquiry, with an evidence of great research and knowledge, and gives an account of the bibliography of applied and descriptive geometry not elsewhere to be found. The scope or readiness of application, and ease of comprehension or study of Culmann's works are not known to us, but we can affirm that the graphical method, is set forth in Prof. Du Bois' work with singular simplicity, and is accompanied by supplemental chapters of analysis with examples for discussion in excellent demonstration. The importance of the graphical method in considering the strength of engineering works can scarcely be overstated; not that it is more easy of application to the problem, or more accurate in final result, for it is in fact only a linear expression of quantities and forces, exhibited in two dimensions, which quantities and forces would otherwise be expressed in figures or algebraic terms, but that its *tangibility* both of process and in completed diagram, is peculiarly satisfactory and devoid of accidental, unavoidable errors. It is a kind of knowledge which once acquired is never lost to the mind, but is at all times afterward available for current use. The neglect of geometry in the studies of our technical schools has been quite marked, and has proceeded principally from the absence of practical application. With this hand book of applied geometry, this branch of mathematical science will be restored to the classes of students in engineering. The work has been published in a superior manner, well suited for its purpose, and although plates in the text would have improved its value to the engineer, after completion of his studies, the atlas of mounted plates is preferable for pupil; and the adoption of the book as a text book in technological schools cannot be too highly recommended.

International Exhibition

1876.



Elevation.

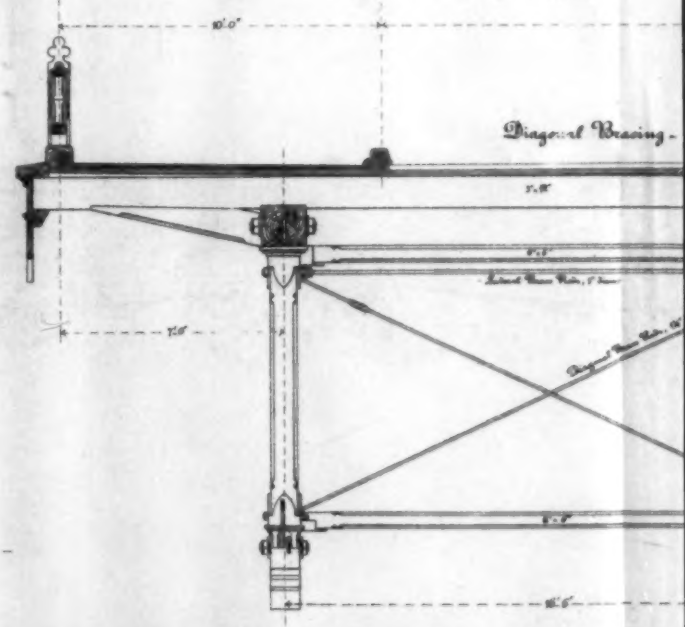


Temporary Road Bridge

over

Lansdowne Valley.

Henry Pettit
& W. Wilson
Engineers



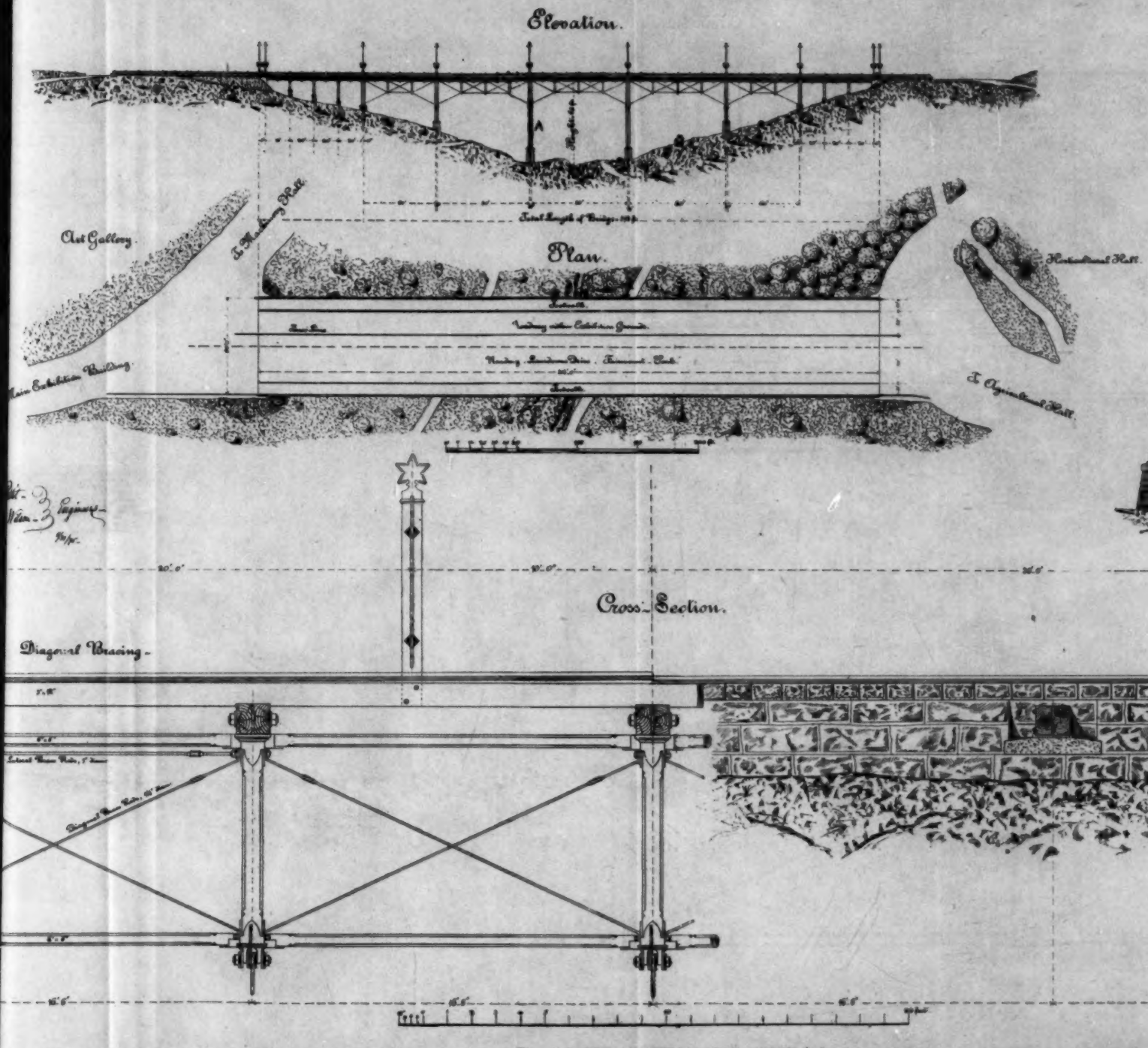
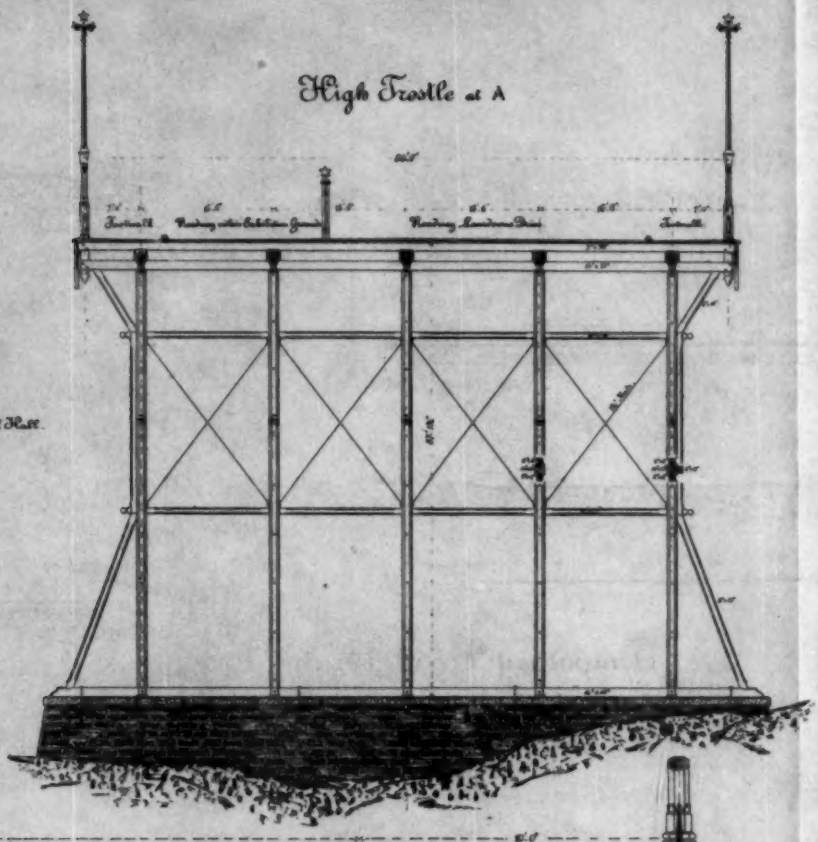
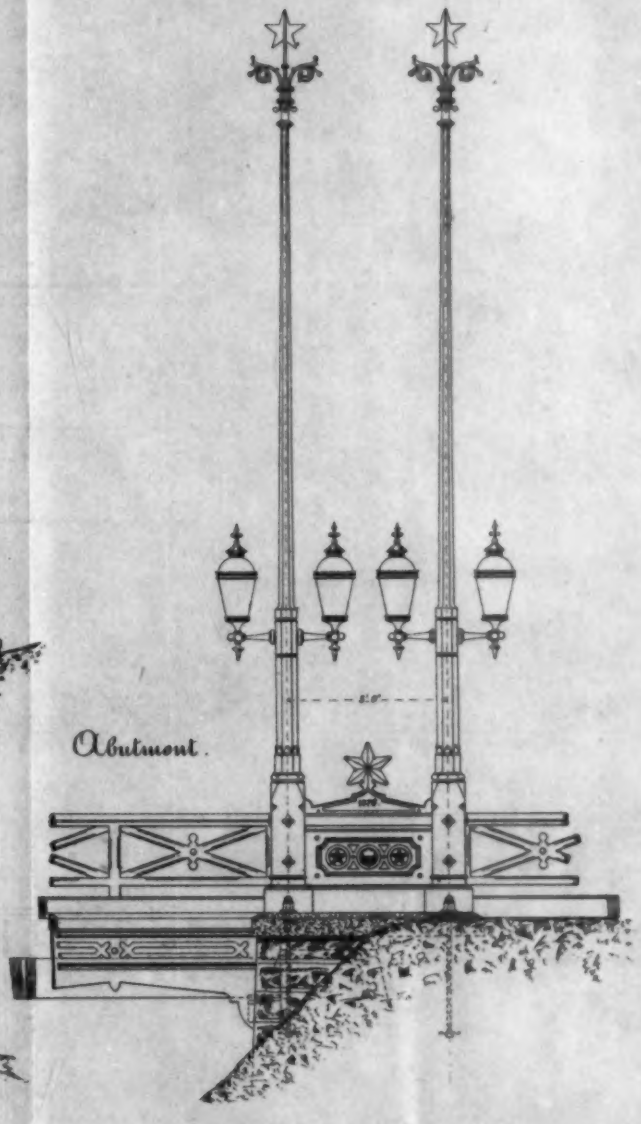



Photo-Litho & Printed by J.H. Camp: 610 Jayne St. Phila'da.

Fairmount Park
Philadelphia

High Trestle at A





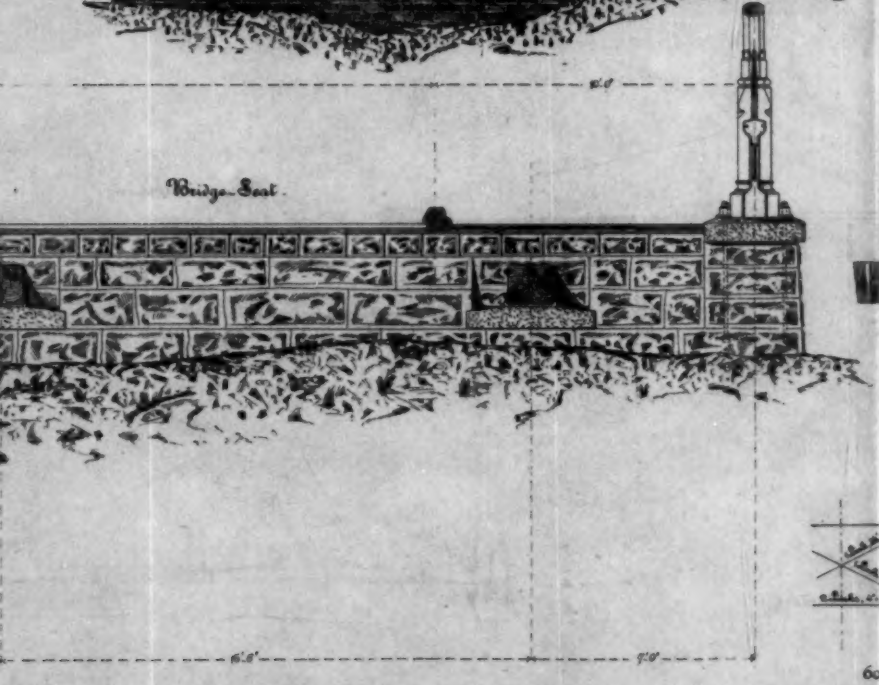
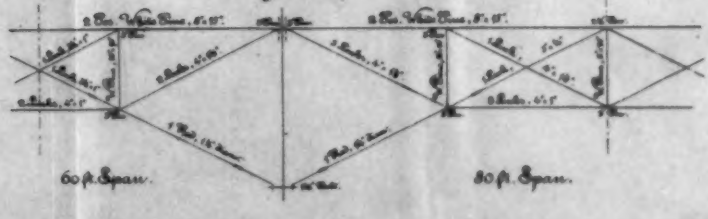
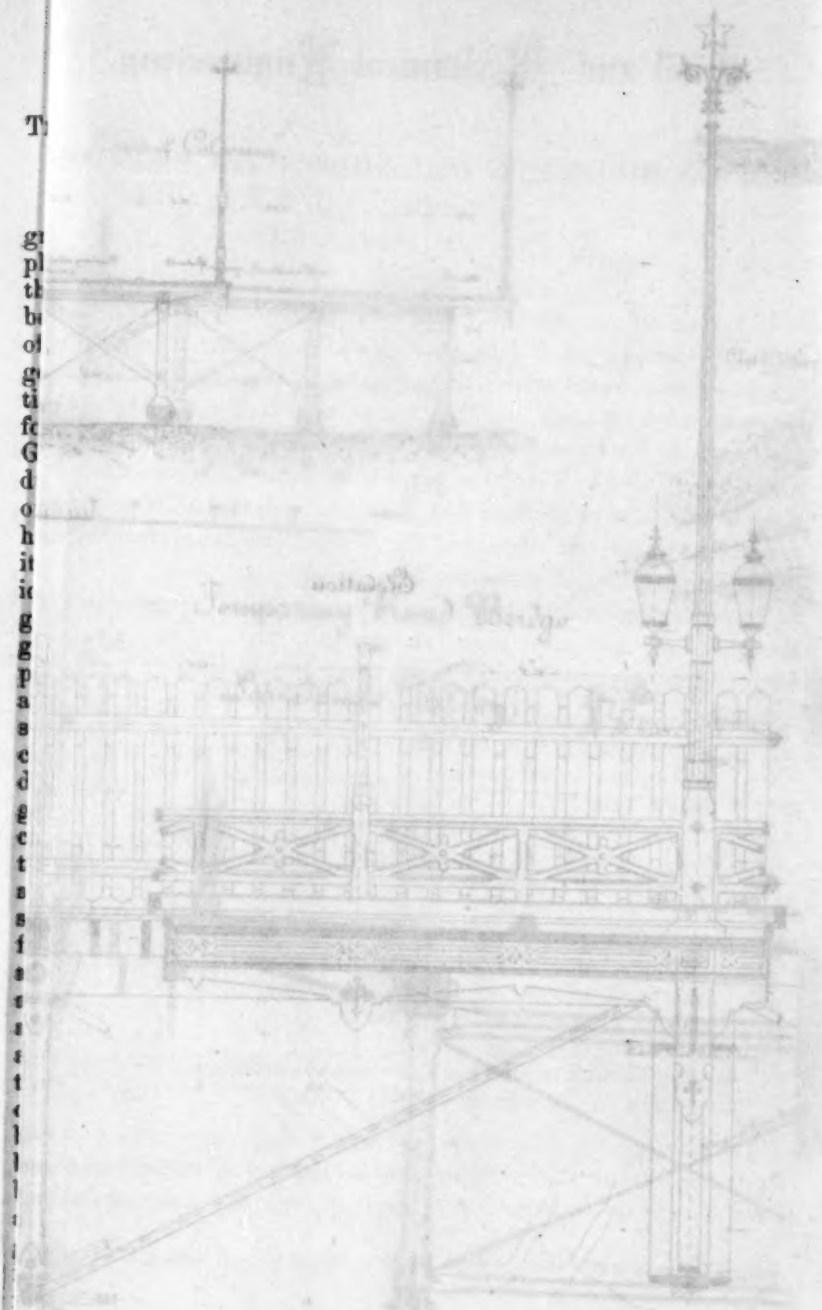




Diagram of Trusses.



T

g
pl
th
b
o
g
ti
fc
G
d
o
h
it
ig
g
p
a
s
e
d
e
c
t
a
s
f
a
t
a
s
t
c
l
l



# Civil and Mechanical Engineering.

## ROAD BRIDGE OVER LANSDOWNE VALLEY, FAIRMOUNT PARK, PHILADELPHIA.

By Joseph M. Wilson, C.E.

In laying out and arranging the grounds which were appropriated by the Commissioners of Fairmount Park for the use of the United States International Centennial Exhibition, it was found advisable to construct a road bridge over the Lansdowne Valley, a deep ravine just north of the Memorial Hall. The plans were accordingly prepared by Mr. Henry Pettit and myself, as joint engineers and architects to the Centennial Board of Finance, and the erection is now proceeding under our direction, the contractors being the Watson Manufacturing Co., of Paterson, New Jersey.

The following description and accompanying plan are presented in the hope that they may prove of interest. The bridge consists of twelve spans, the general dimensions being as follows:

| | |
|---|---|
| 3 Centre Spans, 80 feet each, | 240 feet. |
| 2 Intermediate Spans, 60 feet each, | 120 " |
| 7 End Spans, 20 feet each, | 140 " |
| 6 Spaces over Piers, 10 inches each, | 5 " |
| 2 Spaces over Abutments, 5 feet each, | 10 " |
| Total Length of Superstructure, | 515 " |
| Approach Wall, north end, | 45 " |
| " " south " | 125 " |
| Extreme Length of Railing on Bridge and Approaches, | 685 " |
| Width of Roadway, | 60 " |
| Width of Foot-walks, 10 feet each, | 20 " |
| Total Width of Bridge, | 80 " |
| Distance centre to centre of trusses in the same span, | 15 " |
| Projection of Foot-walks beyond Trusses, | 7½ " |

The spans of 60 and 80 feet consist of single intersection, deck, Pratt trusses with timber upper chords and posts, and wrought iron lower chords and other tension members, vertical diagonal bracing

being introduced between each of the posts in the trusses, and upper lateral bracing between the upper chords of the two outer trusses only, and continued to the abutments at each end. The foundations are of masonry throughout, trestles of timber being erected on the piers. The trestles are framed with combination posts, the pieces firmly bolted and mortised together, forming a stiff rigid system, and vertical diagonal bracing is placed between each of the posts.

Wind ties are introduced, connecting the lower chords of the truss spans with the trestle, those on the outer ends of the 60 feet spans being firmly bolted to the masonry.

The masonry is of the best Conshohocken stone, that in the foundation work being laid with good flat beds, the stone of good size and shape, none averaging less than six cubic feet, and the footing courses projecting 6 inches on all sides. The masonry above ground is rock range work pointed with dark mortar. The coping and cap stones are of Newark sandstone, hammer dressed, with sloping top, and draft on the faces, laid in cement. The lower courses of foundation work for three feet in height, under the trestles and pier columns, are laid in cement; the balance of the work is in strong lime mortar.

The wrought iron work is specified of the best quality, all that in tensile members, viz., carrying links, lower chords, counters, lateral and diagonal braces, wind ties and bolts, of double rolled iron from the muck-bar, and capable of withstanding, on a turned down or grooved section, a tensile stress of 60,000 lbs. per square inch; the links when tested to the breaking strain, if so required by the engineers, to part through the body and not at the head. All joints to be made tight by thickening washers whenever necessary; pins to fit the holes within one-hundredth of their diameter, and sleeve nuts to be introduced in the counter links.

The bearings at top and bottom of posts and on trestles and the finish to hand-rail over abutments are to be of cast iron.

All of the lumber throughout the structure, except where otherwise specified, is of the first quality white pine, free from flaws, shakes, unsound knots, and in every way suitable for the various purposes for which it is intended. The floor beams are of three by twelve inches section, placed 16 inches apart, between centres. The flooring on roadway consists of two thicknesses of two inch plank, the lower layer being of white pine, laid diagonally, and the upper of white oak laid at right angles to the line of travel. The flooring on foot-

walks is also in two thicknesses, the lower layer being two inch white pine, and the upper layer one and a quarter inch yellow pine, tongued and grooved and laid longitudinally to the structure, no boards being allowed over six inches in width. The curb is of white oak.

All the lumber forming the trestles, columns, truss posts, upper chords, and lateral struts throughout the structure is dressed. All parts of the bridge except the flooring and floor joist, are to be painted in three coats in oil of approved tints; the under side of flooring and floor joist to be kalsomined in two coats.

Tin conductors, 3 by 4 inches section, and 3 feet long, are introduced in the flooring next to curb, at the centre of each panel in the roadway, and at 40 feet distances in the foot-walks.

The bridge will no doubt be a favorite resort; commanding a very fine view up the river, and of the ravine beneath it, the floor at the centre being 68 feet above the ground.

---

## VERTICAL BLOWING ENGINES.—THE INTRODUCTION OF VERTICAL BLOWING ENGINES INTO CLEVELAND.*

By Mr. John Gjers, Middlesbrough.

[From *Engineering*, London, October 29, 1875.]

Those conversant with blast furnace plant, will probably remember, that, prior to about 1850, the most prevalent type of blowing engine was the old-fashioned beam engine, of long stroke, varying from 8 feet to 12 feet, and air-flaps arranged on the top and bottom covers, made of strong double leather, sewed together, stiffened with an iron plate riveted on the back. Such engines were made of large size, usually one engine for the whole set of furnaces connected with one plant; such, for instance, as the, at one time, famous engine at the Ebbw Vale Works, with a blowing cylinder of 12 ft. diameter and 12 ft. stroke.

---

* Paper read before the Cleveland Institution of Engineers.

These ponderous beam engines are necessarily of a very expensive construction; the foundations required are of great magnitude, and the whole system is open to the objection that a single disarrangement or breakdown suspends the operation of the whole plant. The large heavy flaps, closing and opening over large ports, are a constant source of anxiety, and difficult to keep in order.

Another type of engine had, to some extent at that time, also been introduced, viz.: the horizontal arrangement—like the beam engine with a long stroke—capable, like it, of running at the slow speed of only about twenty strokes per minute. But the same objectionable heavy flaps, arranged on each cover, stuck to this system, and these engines, as a rule, were not even so satisfactory as the beam engine.

About this period began a general movement among engineers to introduce steam machinery of a direct-acting kind. Engines of short stroke to work at high speed, began to be introduced for stationary purposes, and by some it was thought that this system could be applied with advantage to blowing engines. But the heavy, unmanageable air-flap valves seemed to be an obstacle which would ever prevent blowing engines being run at a high speed.

Foremost among these early workers, as regards blowing engines, was Mr. Archibald Slate, a member of the firm of Messrs. Cochrane and Company, of the Woodside Iron Works, near Dudley, a man of great energy and much inventive talent. He, about 1852, took out a patent for the direct-acting, short stroke, high speed blowing engine, well known by his name; and he was the first to introduce the system of sub-dividing blowing engines, for a plant of furnaces, to something like an engine per furnace. Slate, in his engine, discarded altogether the then, for high speeds, unmanageable flap valve, and introduced an annular casing round the blowing cylinder, working over ports, and actuated from the crankshaft on the principle of the slide valve, opening the ports alternately to the external atmosphere for a supply of air, and to the interior of the casing for the exit of the compressed air. From this casing the compressed air was transferred to the blast tube by means of a sliding face.

These engines, on a large scale, were first introduced at the Ormesby Iron Works, which Messrs. Cochrane and Company erected in 1854. Four horizontally arranged engines, with 50-in. blowing cylinders, and 2 ft. 6 in. stroke, intended to run from 70 to 80 strokes per minute, were put up to blow the four original furnaces. These

engines were sufficiently successful to encourage Mr. Slate to follow them up, but it was felt, for sundry reasons, such as the wear and tear upon the heavy casings, and the difficulty to efficiently lubricate the same, that a vertical arrangement was more desirable, and consequently he designed such an arrangement, and the first pair of Slate's vertical engines were put up by Mr. Edgar Gilkes, at the Tees Iron Works, Messrs. Gilkes, Wilson, Pease and Company. This, then, was the first vertical blowing engine of the direct-acting, short stroke, quick speed kind.

In 1858, when Messrs. Jones, Dunning, and Company were about to erect the Normanby Iron Works, Mr. Edwin Jones, in conjunction with Mr. Richard Howson, designed a somewhat superior arrangement with the steam cylinder at the top, and the blowing cylinder below, and also introduced the improvement of balancing the weight of the casing, and this formed the model for a number of such engines being made. (See Figs. 1a, 1b and 1c, of engraving.) In 1863, Mr. Howson and Mr. Jones introduced some further improvements, with a view of doing away with the objectionable sliding face necessary to transfer the blast from the casing to the blast tube, and subsequently such engines were erected both at a new extension of the Normanby Works, and at Messrs. Samuelson and Company's Newport Iron Works, in 1864. (See Figs. 2a and 2b.)

Previous to this, in 1863, the author of this paper was engaged by Messrs. Lloyd and Company to design the Linthorpe Iron Works, and the question of what kind of blowing engine to be adopted became one of considerable importance. The beam engine was objectionable on account of difficult and treacherous foundations. Slate's engine had to some extent been successful; still there was much to be desired. The casings were not free from a certain amount of loss from leakage, the amount of lubrication necessary was large, and a considerable noise and thud at the opening of the ports was difficult to overcome. It was impossible to arrange the inside lap of the casing so as to meet the requirements of varying pressures of blast, consequently, in practice very little lap was given—hence there was a loss of power from the pressure coming back upon the piston from the casing, before the pressure had sufficiently accumulated in the cylinder. It was also strongly felt by the author, that there was no sufficient reasons why a suitable self-acting flap should not be designed to meet the necessity of the case. The kind of engine, viz., the

short stroke vertical direct-acting one, was determined upon, and such a design of flap valve and grid was produced (see Fig. 3c), which was believed would answer. In conjunction with Mr. Howson, then manager for Mr. John Stevenson, of Canal Foundry, Preston, the engine was designed somewhat on the general arrangement of the Normanby Slate engine, as far as the steam engine part was concerned; but the blowing part of the arrangement was of an entirely novel and hitherto untried construction. (See Figs. 3a and 3b of engraving.)

Four such engines of power sufficient for three engines at a time to blow the four furnaces, were put up and proved without the slightest alteration entirely satisfactory, and continue in work to the present day. One other novelty was introduced in these engines, and it will be seen by the drawing that the suction flaps are not open to the atmosphere of the engine house, as was always usual up to that time, but that on the contrary all the suction flaps as well as the delivery flaps are enclosed in casings, and that the engine thus sucks its supply of air from one tube, and delivers the compressed air into the blast tube on the opposite side, the intention of this being to prevent the rattle of doors and windows, caused by the concussion of the air inside the engine house, and also to avoid the dust and dirt being drawn into the house; a further object being to enable the supply of air to be taken and dealt with as desired from any convenient spot outside. It has also another very desirable effect, namely, it apparently steadies the working of the engine, and causes an actually superior supply of air to the suction flaps, the moment they open at the change of each stroke. This will be better understood if we consider the case of an engine taking its supply direct from the atmosphere; when the suction flaps are closed the air outside is perfectly stationary, and at every change of stroke the air outside has constantly to be started and stopped in its motion. With the suction tube, on the contrary, the whole volume in the tube acquires a nearly constant motion and speed, the momentum of which completely fills each cylinder as it cushions up against the piston, as it slackens its speed towards the end of each stroke. This can be distinctly felt through any small hole in the casing, as an actual puff out of air at the end of each stroke, and amounts in the Ayresome engine suction casing to a water gauge pressure of 4 in. or 5 in., followed by an about similar amount of suction, making altogether a water pressure difference of 9 in. or 10 in. These Linthorpe engines

were thus the first and original short stroke vertical direct-acting blowing engines, working with self-acting flap valves, sucking their air from one tube, and delivering into another, and they have been the type of the whole crop of engines of this class, which have since been made in this and other countries, and the best proof of the favor this class of engines has met with, is the fact that no more Slate's engines have been made since about this date, 1865.

About the end of 1865, Messrs. Stevenson, Jacques, and Company, started their Acklam Iron Works with a new kind of vertical blowing engine of short stroke, arranged with large sliding valves on the top and bottom covers for the ingress and egress of the air. This proved a complete failure, and the engine was altered as well as circumstances would allow by Messrs. Kitsons, of Leeds, and suction flaps on the principle of the Linthorpe ones were placed all round the top and bottom of the cylinder, and similar delivery flaps placed in the original casings on the top and bottom covers. These engines have continued to work satisfactorily ever since, and may thus be said, in their altered state, to be the second example of engine of this type, with the exception that the suction flaps draw their supply of air direct from the atmosphere.

The Tees-side engines of Messrs. Hopkins, Gilkes, and Company, came next; they were arranged by the author, and carried out at the Canal Foundry, Preston, under the superintendence of Mr. Howson. These engines only differ from the Linthorpe ones in having larger cylinders, consequently it was thought advisable to place the valve grids at an angle, as shown, so as to get more room and reduced length of ports; three tiers of flaps on one grid, were also arranged as shown. Three of these engines were arranged to supply blast for two furnaces. (See Figs. 4a to 4e of engraving.)

Another example of the original class of engine arranged by the author, and carried out by Mr. John Stevenson, Preston, is shown in Figs. 5a to 5d of the engraving. This illustrates a further step in the improvement of these engines, whereas in all previous examples, floorings connecting the engine with the walls of the house had been thought indispensable. In these engines no such flooring was provided, but the engine left standing free, entirely independent of the house. A staging was simply provided at the top of casings connecting the engines, and accessible by a spiral staircase, a fur-

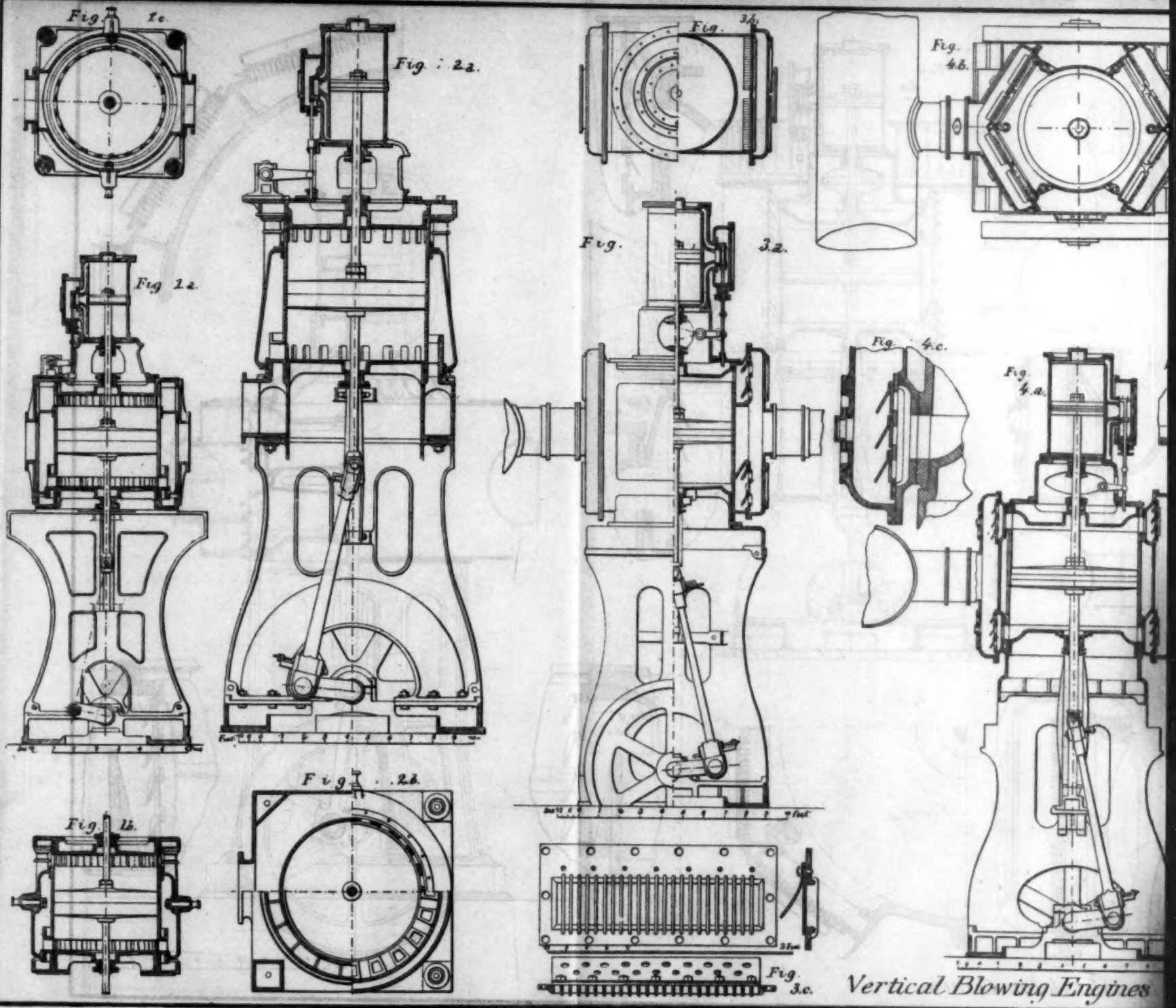
ther small staging to get at the steam cylinder top cover, and one to get at the motion bars was also provided, as shown, and these engines have proved most satisfactory in every respect.

In 1866, Mr. Charles Cochrane, after carefully examining the working of the Linthorpe engine, was so well satisfied of their efficiency, that he determined upon replacing his original Slate's engines at Ormesby Works, with engines of this kind; and under the superintendence of Mr. Downey, two engines were made by Messrs. Cochrane, Grove and Company, from patterns designed by themselves, embodying the principles of the Linthorpe engine; and an engine was produced similar to the drawing showing the "Ayresome" engine, except that instead of being entirely independent, it had floorings at the bottom and top of casings from the engine to the walls of the house, and the stroke being 4 ft. 6 in. instead of 4 ft. In this case the cylinder being the large size of 100 in., it was impracticable to adopt the cast iron casings, and a wrought iron casing was adopted as shown. To get sufficient grid area the flaps were arranged in four tiers and the valve boxes somewhat differently arranged as shown. This large engine proved so satisfactory that Messrs. Cochrane, Grove, and Company afterwards continued for some years to reproduce the same for various other works.

Another modification of the same principle of engine was arranged by the author for the West Yorkshire Iron Company at Ardsley*, near Leeds, and was carried out by Messrs. Cochrane, Grove, and Company, under the superintendence of Mr. Downey. In this case the blowing cylinder was placed at the top, and the steam cylinder below a crosshead working in motion bars between the cylinders, carrying the connecting rods on each side of the steam cylinder to take hold of crank pins on the flywheels. The stroke is 5 ft., the total height of the engine being no more than the 4 ft. stroke engine on the original arrangement. The air flap and casing arrangement is similar to the previously described engine. This general arrangement of engine was the first of its kind, and has been reproduced for several other works, amongst others, by Messrs. Westray and Forster, of Barrow, for the Lofthouse Iron Company.

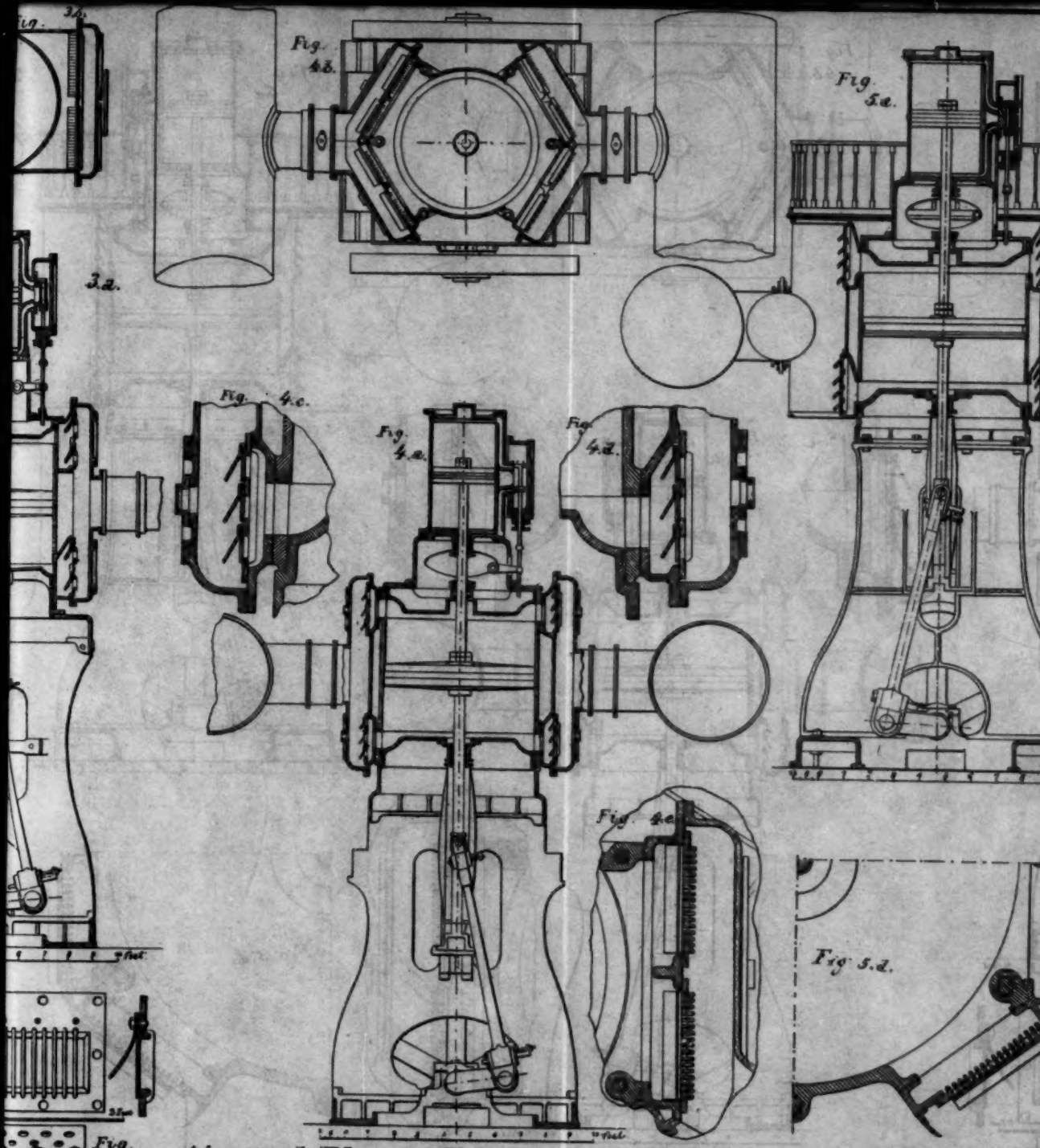
---

* A two-page engraving of these engines was published in *Engineering* for March 4, 1870.




# Vertical Blowing Engines

Photo-Litho. & Printed by J.H. Camp. 630 Jayne St.




Vertical Blowing Engines by Mr. John Ajers.

Photo-Litho. & Printed by J.H. Camp. 610 Jayne St. Phila'da.

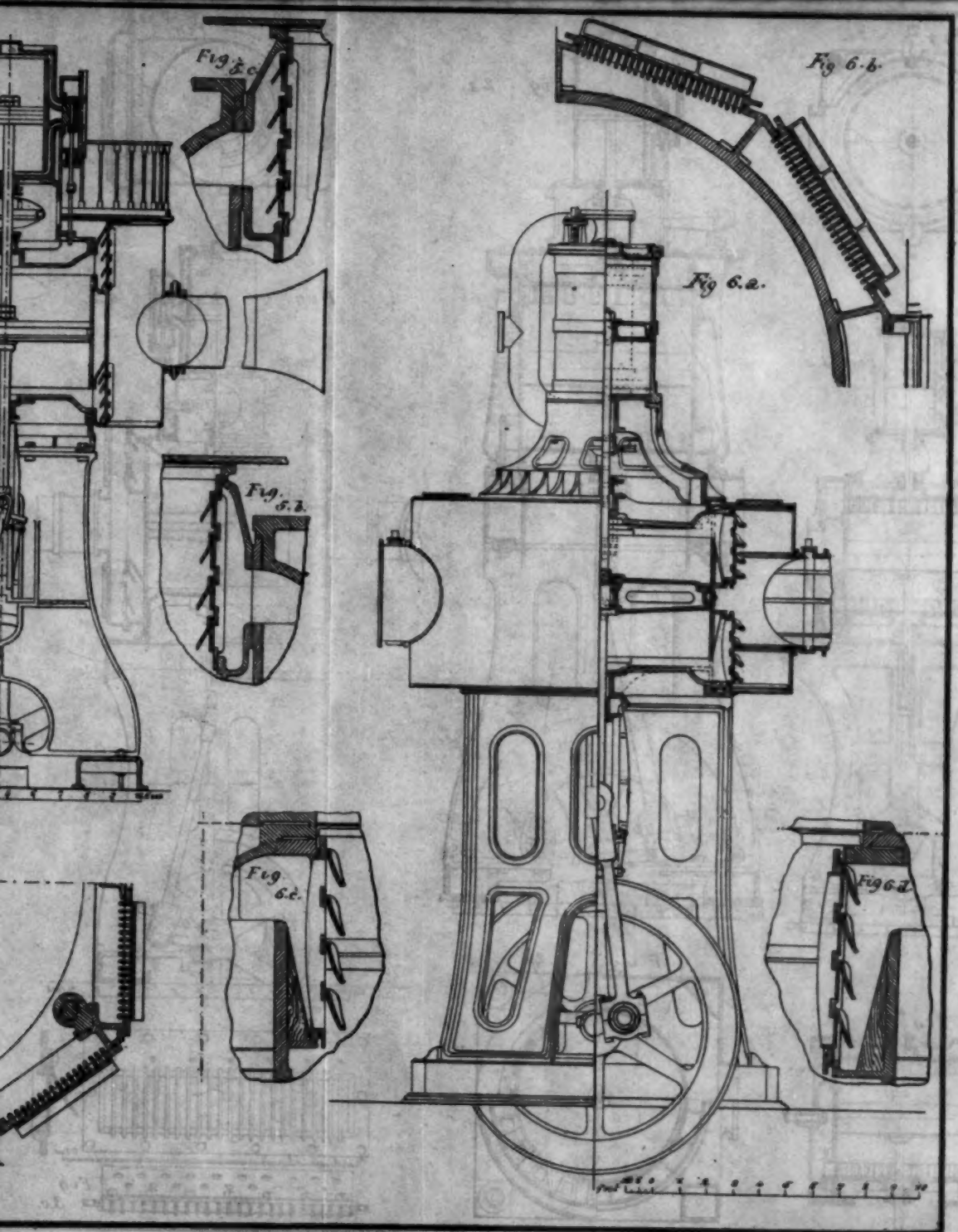


Fig 6.a.
Fig 6.b.
Fig 6.c.
Fig 6.d.
Fig 6.e.
Fig 6.f.

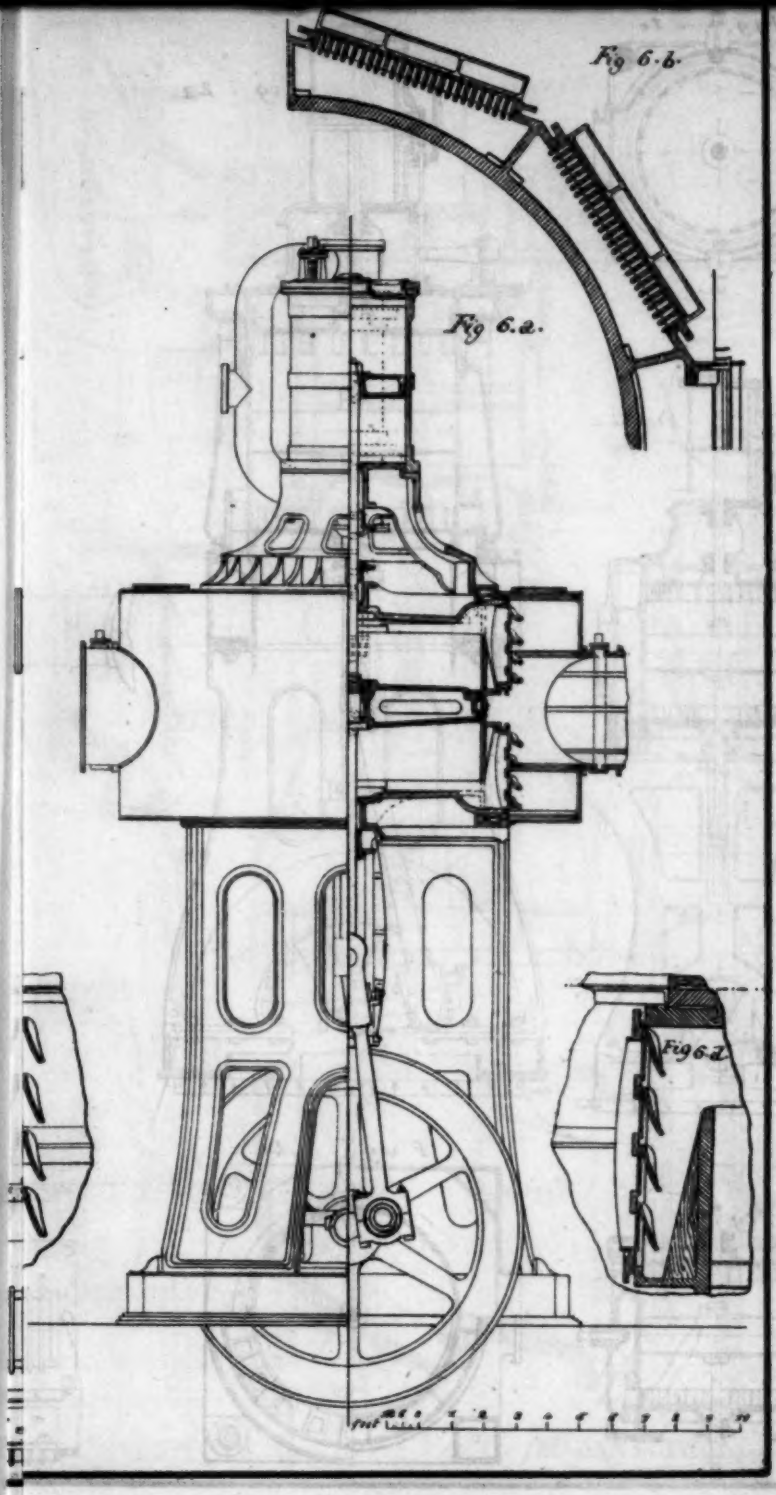


Fig 6.b.
Fig 6.a.
Fig 6.d.

In 1870, when the author had occasion to erect the Ayresome Iron Works for himself and partners, three large engines, two of which should be sufficient to blow four furnaces, were decided upon, and were carried out by Messrs. Cochrane, Grove, and Company, under the superintendence of Mr. Downey. The engines are generally similar to those originally made for the Ormesby Iron Works, except that the stroke was reduced to 4 ft., and the blowing cylinder to 96 in., the steam cylinder being 40 in. A piston valve was also adopted for the distribution of steam in place of the ordinary slide. These engines were similarly arranged to the Frodingham ones, standing entirely free with simple stagings as before described, as shown, and have been most entirely satisfactory. (See Figs. 6a to 6d.)

The peculiarity of the above engines, and in what they differed from the old beam and horizontal kinds is, as will be noticed, a vertical direct-acting short stroke; this they have in common with the earlier kind patented by Slate, and improved by Jones and Howson; but the further peculiarity, and the one which has made them successful in superseding Slate's and other engines—was originated by the author, and carried out in varied detail by Mr. Howson, Mr. Downey, Mr. John C. Stevenson, and himself—consisted in the introduction of a light air-flap, capable of working at any speed, arranged around the top and bottom sides of the cylinder, and enclosed in casings, the suction flaps on one side and the delivery flaps on the other, taking the supply of air from one tube and delivering it into another.

The author believes he is right in stating, that the engines illustrated above are the type of a large class (more or less embodying these principles), now made in various parts of the world, and claiming Cleveland as their birthplace. The class of engine described above have many important advantages over the old beam engine; the first cost is considerably less, they stand in much less room, the cost of the foundation and house is also much less—it may be taken, putting these items together, that the first cost, to blow the same quantity of blast, is not much more than one-half, while maintenance and repairs, blast for blast, is about the same.

But, say the opponents of these engines, there must be a great loss in the short stroke; the compressed air which fills the clearance at the end of each stroke must be lost. The answer is, that running

double the number of strokes, the amount of clearance practically being the same, it is evident that whatsoever the loss (if loss there be) in the 8 ft. stroke, it is doubled in the 4 ft. stroke. It is, however, certain that the amount of such loss in the ordinary pressure blast engine is generally greatly over-estimated, and when it is said, as is often maintained by practical men, that the loss in each stroke is the cube contents of compressed air in the clearance, then it is an error, and one which, if the author can help to dispel, he will feel justified in having taken up your time with this otherwise not very interesting paper.

Referring to Figs. 7a to 7c, to illustrate the theoretical action of the compression of air in a cylinder, and the effect of clearance, and taking the law of Mariotte, that "at constant temperatures the pressure is inversely as the volume," it is clear that in Fig. 7a, which represents a supposed cylinder of 5 ft. stroke, with absolutely no clearance, the air, for example's sake, to be compressed to $3\frac{3}{4}$ lb. above the atmosphere (which is an average blast pressure), and an atmosphere in round numbers to be taken at 15 lb., then $15 + 3\frac{3}{4} = 18\frac{3}{4}$, and 15 to $18\frac{3}{4} =$ 5 vol. to 4 vol.; or in other words for the pressure to increase by one-fourth, the piston would have to travel 1 ft., or reduce the volume by one-fifth, the pressure curve described would be hyperbolic, and with a supposed constant temperature the indicator diagram would be as shown by A B C D. (See Fig. 7a.)

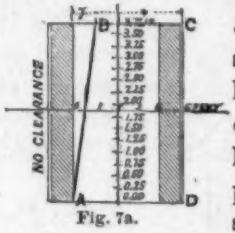


Fig. 7a.

Again, to show the effect of extreme clearance space, say the stroke the same as before, what would be the amount of clearance space measuring for absolutely no blast to be expelled from the cylinder? Supposing constant temperature as before, evidently it would require a clearance represented by 20 ft. of spare cylinder at each end, as it would require the piston to travel 5 ft., or reduce the volume by one-fifth to increase the pressure by one-fourth, that is to bring up the pressure to $3\frac{3}{4}$ lb., in this case the indicator diagram would be simply the curve line E, F, backwards and forwards, enclosing no space, expelling no blast, and representing no power lost. (See Fig. 7b.)

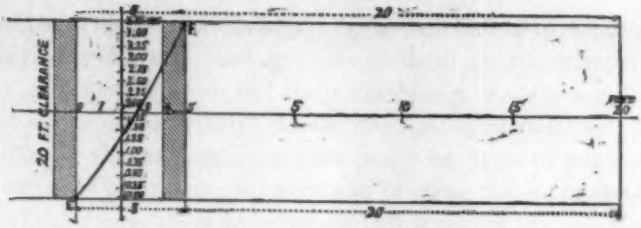



Fig. 7b.

In the same way, it is clear, that if we take the case of a cylinder clearance more nearly approximated in actual practice (see Fig. 26), the same 5 ft. stroke, but a clearance space at each end, equal to a cylinder extension of 5 in., then as before, to increase the pressure, by one-fourth, or to 3¾ lb., it would require the piston to travel 13 in. or reduce the volume by one-fifth; and similarly in coming to the end of the stroke and traveling back, the piston would have to travel 1¼ in. or one-fourth of the 5 in. clearance space before the compressed air in that space had expanded down to atmospheric pressure, or from 18¾ lb. to 15 lb. The diagram lines would be G, H, I, K, in Fig. 7c.

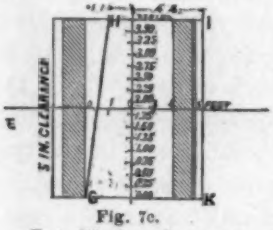



Fig. 7c.

It will thus be seen, with these supposed circumstances, that the diagram proves the loss due to the clearance space to be equal to only 1¼ in. of the travel, or in other words, the actual loss in blowing capacity, at the above pressure, is only one-fourth of the total clearance contents, and not the whole of it, as has erroneously been taken for granted by many practical men. This can be illustrated in another way without the aid of the diagram. It is clear that an engine with a cylinder similar to Fig. 7c would suck in air during 58¾ in. of its stroke, whereas, with actually no clearance, it would suck it in during the whole 60 in. of the stroke, and what is taken in must be given out again.

To apply the above to the actual case of the Ayresome engine, the author begs to refer to diagram Fig. 8a. The pressure actually blown at these works is 4½ lb., and the stroke 4 ft., the total clearance space is equal to a cylinder extension of something more than 7 in., but call it 8 in., the theoretical indicator diagram on this data is A, B, C, D, showing a loss of blowing capacity due to the clearance equal to 2⅓ in.

A number of actual indicator diagrams have been taken, one of which is shown by the thick line on Fig. 8a. It will be seen that the actual diagram shows considerable less loss or only about $\frac{1}{8}$ in. of the stroke. It arises from this, and is one further reason why a moderate clearance space is so objectionable. That, as before stated, the theoretical curve laid down to illustrate the principle is the hyperbolic curve of constant temperature, whereas the actual curve got in practice, nearly assimilates to the adiabatic curve of no heat being abstracted in compression or given out in expansion. Now, you are well aware that when air is compressed in the cylinder the temperature increases considerably, and consequently, as shown by the actual diagram, the pressure increases faster than the volume diminishes, and in the same way the compressed air in the clearance space is brought much quicker down to the atmospheric pressure in consequence of the cooling action in being expanded. The loss then in the Ayresome engine is shown by the actual indicator diagrams to be about $\frac{1}{8}$ in., or one-fifty-fifth part of the stroke, but it is not even correct to call this a loss of power, as the diagram truly represents the power expended in compressing the air which is actually delivered. In reality, the power expended in compressing the air in the clearance space is given back again by that air expanding at the return of each stroke, consequently it is not loss of power, simply loss of capacity for blowing, which, if a 4 ft. stroke engine is compared to a 8 ft. stroke, may amount to say one per cent. less. To compensate for this, it is only necessary to keep the 4 ft. stroke engine at one per cent. higher piston velocity, or make it one per cent. larger piston area—no more steam being consumed—taking no account of the little extra friction. The author entertains the hope that the above has made this truth clear, that within ordinary limits the power required to compress say 1000 cubic feet of air to the ordinary blast furnace pressure is practically independent of what the stroke may be, and that the objections raised against the short stroke blowing engine, have been proved to be as unfounded in theory as they are in practice.

A moderate clearance space in blowing engines for blast furnace purposes is practically considered not objectionable, as the easier working of the flap valves, and steadier working of the engine is thereby facilitated; the author hopes, therefore, also to have proved that within reasonable limits the clearance space is not objectionable, either from a practical or from a theoretical point of view.

The author begs also to point to the actual good work these engines are admittedly doing, as compared with long stroke beam engines of the same calculated capacity, as a further proof that there can be nothing seriously wrong either in the short stroke, nor in any little extra clearance space there may be. A number of indicator diagrams have been taken by the ordinary 10 lb. spring, which show a very perfect working of the blast cylinder in the Ayresome engines.

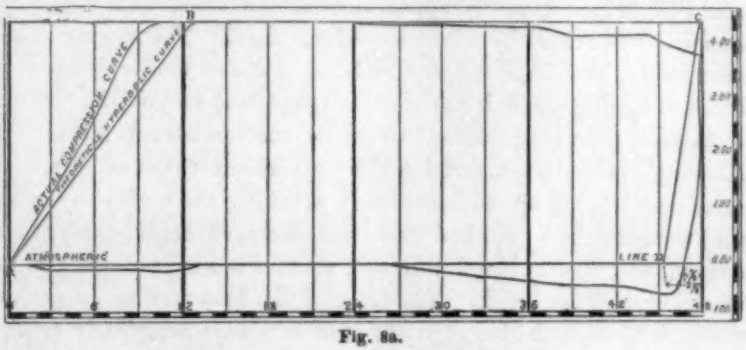



Fig. 8a.

To exhibit this on a larger scale, the author had a 5 lb. spring made, and the diagram Fig. 8a, is from one of those. It is feared, however, that on the suction side, the indicator piston has bobbed the light spring beyond the mark, as the other diagram, taken with the stronger spring, does not point to any unusual suction at the beginning of the stroke.

---

TABLE GIVING PRINCIPAL DIMENSIONS OF THE BLOWING ENGINES, ILLUSTRATED IN CONNECTION WITH MR. GJERS' PAPER.

| Works at which the Engines are working. | Diameter of Steam Cylinder. | Diameter of Blowing Cylinder. | Stroke. | Ratio of Area thro' Valves to Plat'n Area | Speed in Rev'lutions per Minute | Cubic Feet of Air delivered per Minute. | Reference to Figures on Engraving. |
|---|---|---|---|---|---|---|---|
| | in. | in. | ft. in. | | rev. | cub. ft. | |
| Normanby..... | 21 | 56 | 3 0 | 1 : 4 | 40 | 4,100 | Figs. 1a to 1c |
| Newport..... | 31 | 79 | 4 8 | 1 : 5 | 40 | 12,700 | Figs. 2a & 2b |
| Linthorpe..... | 30 | 66 | 4 0 | 1 : 8 | 40 | 7,600 | Figs. 3a to 3c |
| Tees-side..... | 32 | 72 | 4 0 | 1 : 8 | 40 | 9,040 | Figs. 4a to 4c |
| Ardsley..... | 32 | 72 | 5 0 | 1 : 5 | 40 | 11,300 | |
| Frodingham..... | 34 | 78 | 4 0 | 1 : 7 | 40 | 106,000 | Figs. 5a to 5c |
| Ayresome..... | 40 | 96 | 4 0 | 1 : 5 | 40 | 160,000 | Figs. 6a to 6d |

## AMERICAN RAILWAY CARS.*

On the afternoon of Saturday last, the limited express by the Pennsylvania Railroad, from Philadelphia, due here at 2·26 P.M., met with an accident which served to show very clearly the excellence of American car building practice. It was thrown from the track about two miles east of the city of Trenton, and, so far as could be judged from the appearance of the track and switch, the accident was caused by a broken switch stand. The engine passed over safely, but displaced the rails so that the tender jumped the track, dragging after it the mail, baggage, and two of the drawing room cars. Crossing one or two tracks, the cars struck a coal train standing on a side track, and demolished a number of the coal cars, at the same time ripping up and completely wrecking the tracks over which they passed. The road bed itself was damaged considerably, being dug up, and ties cut and torn out, so that it was necessary to lay tracks around the break. The force of the blow was so severe that the ends of both the baggage and mail cars were completely crushed and shivered. Neither mail agent nor express agent in these cars received any injury, however. The two palace cars following, which left the track, were uninjured, save that one of them had a platform broken; the car itself, however, was intact. The coal cars which were struck by the train were completely demolished. The tender, which was wrenched from the engine by the shock, was also destroyed. The distance run was very short, as the engineer put on the brakes before the tender went down. The time in which the power had to act was of course very short, but as the parting of the couplings does not throw the brakes off, they continued their effect until the train stopped. The train was a fast one, and running at a high rate of speed (not much under the rate of forty miles per hour at the time), and with the exception of the baggage and mail cars, it was made up of heavy Pullman drawing room cars. The weight of that part of the train that left the track, with that which did not, could not have been less than 460,000 pounds. Great surprise has been expressed that no one was hurt, and that so little injury was done to

---

* From the *Iron Age*, N. Y., Nov. 18, 1875.

the train. When the construction of these cars is considered, it is nothing to be surprised at, their behavior under the circumstances being what would be expected. The tender, being short, heavily loaded, and by no means as strongly built as a passenger car, was destroyed. Those cars that struck the coal train and rolled loose from their trucks, had their ends broken in, while in the last cars the shock was very light; passengers remarked: "that is a very short stop;" but it was not supposed that an accident had happened. In the cars of this pattern, the amount of resistance offered by the framing is something enormous. Six sills are commonly used, beside two truss planks or their equivalents. In many cases, even more timber than this is put in. The cross section may, we think, be safely set down as about 240 square inches of the best Southern pine, whose crushing stress cannot be less than 6000 pounds per square inch, or a total of 1,440,000 pounds. In the baggage and mail cars the quantity of timber is even greater, since they are framed so as to carry heavier loads. To crush in the end of a car thus framed, as might be expected, is exceedingly difficult, as the blow comes upon the platform, and its force is seriously diminished before it reaches the car body. With a train of cars less strongly framed, the forward ones must certainly have been crushed or telescoped, and the resulting loss of life, would, of necessity, have been heavy. Recent accidents in England, of a very similar character to this one but with trains, so far as we can learn, weighing much less, have resulted in large losses of life. The side doors necessary in compartment cars of the kind used there, are doubtless very convenient at stations, but when, through those same doors, the passenger shot out into a mass of debris during an accident, finds himself a part of the general wreck, and is crushed and ground among springs, wheels, sole-plates and panels, he would, it is safe to assert, willingly exchange the convenience, for more strength and safety. We say confidently that we do not believe it is possible to build cars with compartments and side doors that can in any way approach the strength of the long American car with end doors. The whole floor and side as far as the window sills, is a unit, and the amount of resistance which is offered is something extraordinary, when compared with the coaches used on foreign railroads.

# MILL LIGHTING BY ELECTRICITY.*

By A. TOLHAUSEN.

In spite of the many improvements which have been brought to bear on the various magneto-electrical machines for the generation of light, the use of electricity for lighting up mills or other workshops, in place of common oil or gas, has scarcely been introduced.

The "*Journal für Gasbeleuchtung*," however, recently observes that in the establishment of Messrs. Heilmann, Ducommon & Steinlein, in Mühlhausen, electricity has been applied apparently with success, for lighting-up purposes. In a separate room, four magneto-electrical machines are placed, which feed other four suitably located lamps constructed on the Serrin principle. The dimensions of the room lighted up are 60 meters (196·8 ft.) by 30 meters (98·4 ft.). Each lamp throws off a light equal to about a hundred Carcel lamps, and these are surrounded respectively by a glass globe which serves to blend the light intensity. The cost of the four lamps, excluding the maintenance of the motive power, averages about ten pence per hour.

During the three months which this electrical light has been working, no inconvenience has been experienced, the light given off being beautiful and steady, and uncomparable to any other mode of illumination. The magneto-electrical machines have each cost 1500 frcs., or sixty pounds sterling, the whole arrangement amounting to 8000 frcs., or £320.

| Table of comparative cost of electric light with other means of illumination. | Quantity of material required for producing light = 1 stearine candle. | Cost of a light intensity = to that of 700 stearine candles per hour. |
|---|---|---|
| Electrical light obtained by a magneto-electrical apparatus, . . . | . . . | 1*s.* 2*d.* |
| Ditto galvanic pile, . . . . | . . . | 2*s.* 6*d.* 4*s.* 2*d.* |
| Coal Gas, . . . . . | 0·53 cubic feet. | 2*s.* 8*d.* |
| Oil, (vegetable) . . . . | 79·92 grains. . | 5*s.* 1*d.* |
| Tallow candle, . . . . . | 162·02 " . | 10*s.* 6*d.* |
| Stearine, . . . . . | 160·47 " . | 21*s.* 10*d.* |
| Wax, . . . . . | 127·45 " . | 27*s.* |

In the preceding table, the following prices have been assumed: gas per cubic meter = 3*d.*; tallow, 17*d.* per kilogram; stearine candles, 3*s.* per kilogram; wax candles, 4*s.* 2*d.* per kilogram.

*From the *Electrical News*, Nov. 1, 1875.

To distribute the effect of the electric light in various directions and points in a uniform manner, the attempt has been made to pass the current through the different apparatuses by means of current deflectors, which break the currents passing through the lamps during so short a period, as to make the light appear to all intents and purposes as being continuous. The fact has been hereby utilized, that the impression made by light upon our visual organ remains intact during at least one-tenth of a second's duration. Moreover, the luminar arc between the carbon points becomes momentarily reproduced, provided the current interruptions are of only minute duration, a fact which has been repeatedly proved by the illuminating apparatuses of Siemens and Halske, as of late improved by Hafener Alteneck. Leroux has himself determined by experiments that the luminous arc between the carbon points becomes instantaneously reproduced, provided the interruption of the current does not exceed one-twentieth of a second. This last-mentioned authority also succeeded in dividing the electrical light by employing a rapid turning deflector, by means of which he alternately conducted the current of Bunsen's battery to two lamps, in such a manner that each of these received an equal amount of currents in equal times ; the luminosity given out by these was also equal in both lamps.

On the other hand, it would appear that this *modus operandi* is neither cheap nor practical, and it has therefore been further attempted to divide the electric light without having recourse to the luminous arc. The results, however, have not been satisfactory, inasmuch as the cost of such illuminations rank almost equal to those of gas or petroleum lighting. These futile attempts induced Gramme to construct smaller machines with an equivalent light intensity of fifty Carcel lamps. These small lamps work very well alone; the light emitted is not perfectly steady; the best of the machines yet introduced, present a light of at least one hundred Carcel lamps, with an average cost price of £60.

Although the foregone description does not solve the problem concerning the devisability of the electric light, it is possible that the modern improvements made in this direction, coupled with the reduced cost, may at no distant period lead to the lighting up of our mills, railway stations, etc., by means of electricity.

## THE WEAR AND REPAIRS OF PUMPING ENGINES.

A communication from Mr. H. R. Worthington, the inventor and constructor of the most successful direct acting pumping engine in the United States, complains with some reason of the statements made by Mr. E. D. Leavitt at the annual meeting of the American Society of Civil Engineers, in June, 1875, and was re-published from the transactions of the society in the JOURNAL, Vol. C, page 305, (Nov. 1875).

Mr. Leavitt's remarks as quoted in the JOURNAL were:

"The superiority of beam engines in respect to low cost for repairs is very clearly shown by the returns from Chicago, Louisville and Cleveland—this item, in many cases, ranks second to fuel only—and it is worthy of remark that at Chicago, with a duty of only 44,750,000 feet pounds; and coal at $8.56 per ton, water was delivered for 9·671 cents—while at Salem, with a duty of 59,000,000 feet pounds, and coal at $7.14 per ton, it costs 12.156 cents—per million gallons raised one foot high."

Mr. Worthington takes issue as to the facts set forth in these statements, and offers the following to substantiate his grounds.

Supposing an American duty of 44,750,000 at Chicago, and coal at $8.56 per ton of 2000 lbs. The cost of coal, per million of gallons raised one foot high, becomes 7·97 cents. While with the ratios of duty and price of coal at Salem given above, the cost of coal per million of gallons raised one foot high at that place becomes 5 cents. This leaves the cost of 1·701 cents at Chicago, and 7·156 cents at Salem, per million of gallons raised one foot high, to represent what Mr. Leavitt considers repairs of engine. The figures which form the basis of this estimate are questionable, and would doubtless change materially if scrutiny is made of them, and care be taken to remove the extraneous items of boiler repairs, etc., etc., and to equalize the proportion of cost of attendance, which becomes less per million as the number of millions increase. We will only refer to some data sent us by Mr. Worthington to show what discrepancy of statement exists. In making up the items which form the groundwork for for 12·156 cents, it appears that the cost of engineer, firemen and laborers was $2420.00, while the cost of coal was $3839.12; following this proportion the cost of attendance becomes 3·15 cents per million gallons. Now the relative cost of attendance at St. Louis could not

vary much from that at Salem, and if anything like 3·15 cents was incurred, the *profit* resulting from repairs of the St. Louis engine was something surprising. In the absence of reliable data, we need not follow this line of argument; in fact, there is but little connection between the final cost of water per million of gallons, and the repair-cost of an engine, which may be properly chargeable to the year when the repairs were made, and no comparison should be based upon it.

Repairs to an engine are the consequence of definite conditions, and proceed from wear or failure of parts; the comparison to be instituted, therefore, is what special liability does a type of engine present to be wasteful, in regard to wear or liability to accidental injury. Wear represents inordinate friction—improper facilities for lubrication—unsuitable arrangement of parts to avoid deposits upon the wearing surfaces, unnecessary carriage of moving weights. Does a beam engine, *per se*, possess any advantage in these regards over a direct acting engine, *per se?* Great expense, or in fact, any material expense for restoring the beam-centre pins or blocks; or for a fly-wheel engine; the main shaft or its blocks, or its crank pins; the repairs of a parallel motion, or any of the wrist pins; are tokens of improper construction, and are not to be assumed as defects of the kind. If an engineer or builder uses a slide for his cross-head, in lieu of a parallel motion, he measures the economy of construction against the economy of coal—if he so disproportions the surface of his slides that they wear out rapidly, he also measures the economy of construction against the economy of repairs; but the value of the type of engine is not affected by these considerations.

There are classes of engines where the type fails; there is a limit of economical possibility of expansion in a single cylinder engine, no matter how cunning the admission of steam, or how great the mass whose momentum absorbs the shocks, or distributes the inequalities of pressure, and this limit is quickly attained in water works' engines where the mass is omitted. And a similar limit is reached in a double cylinder rotation engine, when the attempt is made to run it for high duty with inadequate momentum.

Shocks, wear and breakage will ensue when this limit is passed.

There can be no question whatever but that horizontal or inclined cylinders must have an argument of comparative economy of original construction, with cost of restoring the pistons or cylinders at stated intervals; but this question does not apply to the broad one of

whether the direct acting or the beam engine is to be the type of the future. Even the *cost* of preserving cylinders of different engines is not to be accepted as a standard for their proper duration; if the iron of a cylinder is improperly soft, if the packings are improperly set out, if they are not set out at all, if bad oil is used, if neglect is permitted, and many other contingencies, will make the best arranged cylinder the least durable. In brief, the limit of performance of the expansive steam engine with mass, with boilers of the highest evaporative quality, is about 130 millions per 100 lbs. burned, while that of engines without mass is about 80 millions per 100 lbs. burned. A yearly average performance will scarcely be two-thirds these values. The cost of attendance will be *about* proportionate to the duty, but we think the higher grade of engine will cost somewhat the most, relatively; unfortunately the prime cost is against the higher engine, and the interest of investment can be computed against cost of attendance, coal or boilers. The writer has upon a previous occasion questioned the fairness of using the final statements of cost of water pumped per million gallons, by different cities, regardless of cost or nature of fuel, of expenses for repairs or ornament, of cost of attendance or salaries; as applicable to the profit and loss of special engines, and the result of this particular example is a vindication of his views. B.

**Original Publication of the Discovery that Flame Proceeds from Ignition of a Gas.**—A curious question of priority has lately been discussed by the French Academy. It was to determine who is the first author that cited the experiment of the two candles as proving that flame is a phenomenon produced by ignition of gas. M. Melsens, in a recent historic disquisition on Van Helmont, attributed the first mention of the experiment to him. M. Chevreul said it had previously been described by Artephines, an Arabian alchemist of the second century. M. Calliburcés, having gone into the subject, first vindicated the priority for Galen, but later, found that Aristotle had spoken of the experiment five centuries earlier. In his "Meteorologica," Aristotle, to explain some luminous meteorological phenomena, compares them to the conflagration of gas which emanates from the wick of a candle recently extinguished. He was thus led to give an exact definition of flame; one which does not differ essentially from those of Newton and Davy.

## AMERICAN FOG-SIGNALS.

It is gratifying to our national pride to know that in all relating to that most important aid to navigation—the method or methods of giving notice to the bewildered mariner blinded by dense fogs, of the presence of dangerous rocks or shoals along a coast, or of the direction of safe channels and harbors—the United States Government has been very decidedly in advance of all other maritime powers.

Major G. H. Elliott, commissioned by the U. S. Lighthouse Board, under the sanction of the honorable Secretary of the Treasury, to make a tour of inspection of European Lighthouse establishments in 1873, in his valuable report, published by the Senate in 1874, remarks, after alluding to the question of the best illuminants for lighthouses: "I will only add that while the British and French systems are necessarily very much like our own, I saw many details of construction and administration which we can adopt to advantage, while there are many in which we excel. Our shore fog-signals, particularly, are vastly superior both in number and power." (*Report*, p. 12).

In the appendix to the U. S. Lighthouse Report for 1874, the chairman of the board, Prof. Henry, has given an interesting account "of the operations of the Lighthouse Board relative to fog-signals." Fog, the great danger and dread of the mariner, cannot be penetrated by the most brilliant of lights; and hence lighthouses, whatever their appointments, are quite valueless in this dire emergency. "The only means at present known for obviating the difficulty is that of employing powerful sounding instruments which may be heard at a sufficient distance through the fog to give timely warning of impending danger." (*Rep.* p. 83.)

"At the beginning of the operations of the lighthouse board, such instruments were employed for producing sound as had been used in other countries; these consisted of gongs, bells, guns, horns, etc. The bells were actuated by clock machinery, which was wound up from time to time, and struck at intervals of regular sequence, by which their position might be identified," (p. 85).

"Guns have been employed on the United States coast, first under the direction of General Bates, engineer of the twelfth district, at Point Bonita, San Francisco Bay, California. The gun at this station consisted of a 24-pounder, furnished by the War Depart-

ment. . . . Notice to mariners was given that after the 8th of August, 1856, a signal gun would be fired every hour and half hour, night and day, during foggy or thick weather. The first year 1,890 rounds were fired. These consumed 5,560 pounds of powder, at a cost of $1,487." (p. 85.) "This signal has been abandoned because of the danger attending its use, the length of the intervals between the successive explosions, and the brief duration of the sound, which renders it difficult to determine with accuracy its direction," (p. 86).

"Experiments in 1855. The lighthouse board was not content with the employment alone of the fog-signals in ordinary use, but directed a series of experiments in order to improve this branch of its service. For this purpose, the board employed Prof. J. H. Alexander, of Baltimore, who made a report on the subject, which was published among the documents. The investigations of Prof. Alexander related especially to the use of the locomotive steam-whistle as a fog-signal, and in his report he details the results of a series of experiments in regard to the nature and adjustment of the whistle, the quantity of steam necessary to actuate it, with suggestions as to its general economy and management," (p. 86).

"Mr. Daboll, of New London, Conn., had for several years been experimenting on his own account with reference to a fog-signal. His plan consisted in employing a reed trumpet, constructed after the manner of a clarionet, and sounded by means of air condensed in a reservoir, the condensation being produced by horse-power operating through suitable machinery. . . Mr. Daboll after this presented to the board a modification of his invention, in which a hot air engine of Ericsson's patent was substituted as the motive power instead of the horse," (p. 87). Mr. Daboll obtained a patent for his fog-trumpet, June 26th, 1860.

With reference to the various schemes proposed by inventors and patentees for sounding bells, whistles and horns, either by hand-power, or automatically, by the action of waves or of rolling vessels, Prof. Henry remarks, "the experiments which were made at this time, as well as all that have been made subsequently, conclusively prove that the penetrating power of the sound for practical use as a fog-signal depends upon the intensity of the motive energy employed. No instrument operated through levers and pumps by hand power, is sufficient for the purpose," (p. 89).

"The penetrating power of the whistle was compared with a Daboll trumpet, actuated by an Ericsson engine of about the same power. . . . The result was that the penetrating power of the trumpet was nearly double that of the whistle," (p. 90).

In October, 1867, a series of careful experiments was instituted at Sandy Hook, a bold headland projecting northward from the north-eastern coast of New Jersey, toward the harbor of New York city. "The principal object of these investigations was to compare different instruments, and to ascertain the improvements which had been made in them since the date of the last investigations, especially the examination of a new fog-signal called the siren, and the comparison of it with the Daboll trumpet," (p. 93). In this instrument, instead of a vibrating steel tongue or reed, a disk-valve in rapid rotation gives the periodic intermission or vibration to the air, or steam blast, requisite to produce a continuous or musical sound. "Under the direction of the lighthouse board, Mr. Brown, of New York, had made a series of experiments on this instrument in reference to its adoption as a fog-signal, and these experiments have been eminently successful," (p. 94). Mr. F. Brown obtained a patent for this instrument July 23d, 1867. The three instruments employed for comparison were:

1st. A Daboll trumpet of the largest size, being 17 feet long, 38 inches wide at its mouth, and carrying in its smaller end a vibrating steel tongue, or "reed" 10 inches long, and 2¾ inches wide, tapering in thickness from 1 inch at its fixed end, to half an inch at its free end. This instrument was arranged to give under a pressure of 15 to 30 pounds per square inch, a blast of five seconds duration, once a minute.

2d. A siren of about the same size, having its rotating disk valve arranged to give about 400 impulses or vibrations of air per second, and operated by a steam pressure varying from 50 pounds to 100 pounds to the square inch.

3d. A steam whistle having its cup 8 inches in diameter, and operated by the same pressures. A steam whistle previously used had its cup 12 inches in diameter and 20 inches long.

The siren was found to exceed the steam whistle in distance of penetration, in the ratio of 2 to 1, and the trumpet in the ratio of 58 to 50; but using a considerably higher pressure. Varying the pressure of steam on the siren, however, from 20 pounds to 100

pounds per square inch, increased the range of the instrument only from 51 to 61. That is to say, five times the pressure gave only about one-fifth additional penetrating power. "At the conclusion of the experiments at Sandy Hook, the siren was adopted as a fog-signal, in addition to the reed-trumpet and the locomotive whistle, to be applied to the most important stations, while large bells were retained for points at which fog signals were required to be heard at but comparatively small distances," (p. 99).

General Duane, the engineer in charge of the first and second lighthouse districts (embracing the coast of New England) under the direction of the lighthouse board made comparative experiments with these three signals, in 1871, and found that a first-class Daboll trumpet, a 12 inch steam whistle, and a first-class siren had the relative powers of 4, 7, and 9. The trumpet was audible at a distance of 12 miles, the whistle about 20 miles, and the siren farther, but how much was not ascertained. The relative expenditure for fuel was: for the trumpet 1, for the whistle 3, for the siren 9, (p. 101). From which General Duane concludes, "It will thus be seen that the siren is the most expensive of the fog-signals as regards maintenance, and that it is adapted only to such stations as are abundantly supplied with water and situated in the vicinity of machine shops where the necessary repairs can be promptly made. On the other hand as it is the most powerful signal, there are certain stations where it should have the preference. . . The steam whistle is the simplest in construction, most easily managed, and kept in repair, and requires the least attention of all the fog-signals. It is sufficiently powerful for most localities, while its consumption of fuel and water is moderate. . . The Daboll trumpet operated by a caloric engine, should only be employed in exceptional cases, such as at stations where no water can be procured," (p. 102). The difficulty of obtaining fresh water is at many stations very great.

Prof. Henry expresses a preference for the most powerful sounding apparatus for a fog-signal, and says: "In the foregoing remark we think the General has expressed a somewhat undue partiality for the whistle, and somewhat over-estimated the defects of the other instruments. The trumpets with Ericsson engine have not been abandoned. . . . They are preferred by General Woodruff, who finds no difficulty in keeping them in repair," (p. 102.)

Turning now to recent English investigations on fog-signals, instituted by the Trinity House, of London, during the year 1873, and

principally conducted by Prof. Tyndall, we find a remarkably concordant testimony as to the value of these instruments. Prof. Tyndall in his report to the Trinity House remarks: "To the late Mr. Daboll, of the United States, belongs the credit of bringing large trumpets into use as fog-signals. At Dungeness one of his [horns had been erected under his own superintendence; and wishing to make myself acquainted with its performance, we steamed thither to-day. (Oct. 15, 1873.) On examining the horn, I was struck by its similarity in all essential particulars to the horns employed at the South Foreland. Considerable improvements in the working of the horn have been introduced by Mr. Holmes, but the horn itself is substantially that of Daboll," (cited in Maj. Elliott's *Report*, p. 40). The English patent of Mr. F. H. Holmes for this fog-signal, is eleven years later than the American patent of Mr. C. L. Daboll, being dated March 14, 1871; and the only essential difference or "improvement" therein indicated is an intermittent horizontal rotation mechanically given to the Daboll trumpet.

Prof. Tyndall also remarks: "On the 8th of October another instrument which has played a specially important part in these observations, was introduced. This was a steam siren, constructed and patented by Mr. Brown of New York, and introduced by Prof. Henry into the lighthouse system of the United States. As an example of international courtesy worthy of imitation, I refer with pleasure to the fact, that when informed by Major Elliott, of the United States army, that our experiments had begun, the lighthouse board at Washington, of their own spontaneous kindness, forwarded to us for trial a very noble instrument of this description, which was immediately mounted at the South Foreland."—(*Pop. Science Monthly*, March, 1875, vol. vi, p. 543.)

Prof. Tyndall made the curious observation, frequently repeated, that in certain peculiar states of the atmosphere an inferior sounding instrument can be heard at a greater distance than a superior one. Details of these remarkable results are given in his treatise on "Sound," 3d edition. On October 17th, "at 11·30 A.M. the mastery of the siren over the gun was pronounced; at 12·30 the gun slightly surpassed the siren; at 1, 2 and 2·30 P.M. the gun also asserted its mastery." On October 21st, "at 11 A.M., distance 6½ miles, when the siren made itself heard through the noises of wind, sea, and paddles, the gun was fired, but though listened for with all

attention, no sound was heard. . . On the 27th also the siren was triumphant; and on three several occasions on the 29th its mastery over the gun was very decided. Such experiments yield new conceptions as to the scattering of sound in the atmosphere."—(*Sound*, p. 314.)

Prof. Tyndall concludes: "An absolutely uniform superiority on all days cannot be conceded to any one of the instruments subjected to examination; still our observations have been so numerous and long continued as to enable us to come to the sure conclusion that on the whole the steam siren is beyond question the most powerful fog-signal which has hitherto been tried in England. It is specially powerful when local noises, such as those of wind, rigging, breaking waves, shore surf, and the rattle of pebbles, have to be overcome. Its density, quality, pitch and penetration render it dominant over such noises after all other signal sounds have succumbed. I have not, therefore, hesitated to recommend the introduction of the siren as a coast signal," (*Sound*, p. 316). And in a communication to the Royal Institution, Jan. 16, 1874, Prof. Tyndall says: "Of all the instruments hitherto examined by us, the siren comes nearest to the fulfillment of this condition; [an energy sufficient to survive a large amount of dissipation;] and its establishment upon our coasts will in my opinion prove an incalculable boon to the mariner."—(*Proceedings Roy. Inst.*, vol. 7, p. 178.)

Sir Frederick Arrow, the deputy master of the Trinity House, and executive officer of the lighthouse service of England, bears the similar testimony, that the instruments employed "have varied in a remarkable manner at different times, but for general efficiency there is no doubt that the American siren takes the first place," (Elliott's *Rep.*, p. 62). Sir Frederick Arrow had previously (in the summer of 1872), visited our country with the special view of examining into our system of fog-signalling, and had accompanied Professor Henry in some of his experimental observations in the harbor of Portland on the coast of Maine.

The three most powerful and trustworthy fog-signals now known —the steam whistle, the fog trumpet and the siren, are thus seen to be of American invention and introduction; and it would be unjust to close this notice without the distinct recognition and record that to the careful and laborious investigations and experiments of the

distinguished chairman of the lighthouse board, Professor Henry, prolonged through a series of years and prosecuted under a great variety of conditions, is largely to be attributed the acknowledged superiority of our fog-signal service.

Professor Tyndall in his article "On the Motions of Sound," published in the *Pop. Science Monthly* for August, 1875, (p. 420), after very briefly alluding to a few of Prof. Henry's researches on the characteristics of sounding instruments, as applicable to the purposes of the lighthouse board, pays him this fitting tribute: "Add to this the fact that their eminent chairman gives his services gratuitously, conducting without fee or reward experiments and observations of the character here revealed, and I think it will be conceded that he not only deserves well of his own country, but also sets his younger scientific contemporaries, both in his country and ours, an example of high minded devotion." T.

---

## HIGH CHIMNEYS.

From *The Builder*, London, Nov. 20th, 1875, we extract the following description and dimensions of two chimneys:—

The first, at the Crawford Street Chemical Works, Port Dundos, Glasgow, has a total height from foundation to top of coping of 468 ft., and from ground line to summit, 454 ft., the outside diameter at foundation being 50 ft., and at ground surface 32 ft., and at top of coping, 12 ft. 8 in. The number of bricks is as follows:—

| | |
|---|---|
| Common Bricks in shaft, . . . . . | 1,142,532 |
| Composition and fire bricks for inside cone, . . . . | 157,468 |
| Common bricks for flues, . . . . . | 100,000 |
| Total number of bricks . . | 1,400,000 |

Weight of bricks about 5000 tons.

The second, at the Kay Street Machine Works, Bolton, Lancashire, has a total height from ground level of 367 ft. 6 in. Octagonal on plan, 14 ft. on every side, or 112 ft. in girth at bottom; 5 ft. 6 in. on every side, or 44 ft. girth, at top. Thickness of brickwork at bottom, 8 ft.; thickness of brickwork at top, 1ft. 6 in. 800,000 bricks and 120 tons of stonework were used.

The top, with cornice and mouldings, required 30 tons of stone and cement.

# Chemistry, Physics, Technology, etc.

## THE DIATHERMACY OF MOIST AIR.

By J. L. Hoorweg.

*Translated from Poggendorf's Annalen, by C. B. Dudley, Ph.D.*

In the year 1861, Tyndall communicated to the Royal Society, of London, a series of experiments upon the absorption of radiant heat by gases, which, in the following year was extended by experiments upon vapors. Tyndall employed the following apparatus: A very sensitive thermo-pile was fitted with two reflectors. On both sides of the thermo-pile, at appropriate distances, two sources of heat were placed. Between the thermo-pile and one source of heat was a horizontal brass tube, some three feet long, closed at both ends by rock salt plates, and connected through side openings with drying apparatus and air pump. When the experimental tube was exhausted, both sources of heat produced an equal effect on the thermo-pile; if, therefore, the entering gases or vapors produced a perceptible absorption, this could readily be perceived by the deviation of the galvanometer needle.

At the same time with Tyndall, and at first without knowing of his experiments, Magnus was occupied with the same subject. In his case, a thermo-pile was fastened to the plate of an air pump. Over the pile was placed a glass vessel, open at the bottom, and which fitted air-tight to the pump plate. This vessel had two openings, one perpendicularly over the pile, and the other to the side of it. Through the last, passed a brass rod, which carried a screen; through the first, a tube, to which a larger glass vessel was cemented air-tight, and which carried above a second glass vessel containing boiling water. The gases whose absorption was to be observed, were let into the larger glass vessel by a stop-cock.

The results of these two fine series of investigations may be said to agree very well in general. It is with difficulty, however, that this is seen in the following table:

| Name. | Absorption of gases according to Tyndall. | Diathermacy of gases according to Magnus |
|---|---|---|
| Air, | 1 | 100· |
| Oxygen, | 1 | 100· |
| Hydrogen, | 1 | 96·5 |
| Carbonic Oxide, | 90 | 88·8 |
| Carbonic Acid, | 90 | 90·3 |
| Nitrous Oxide, | 355 | 83·3 |
| Marsh Gas, | 403 | 81·2 |
| Olefiant Gas, | 970 | 52·1 |
| Ammonia, | 1197 | 43·7 |

Tyndall employed a tube 2 feet 8 inches long, Magnus one of 10 inches. By the following considerations, the agreement may, perhaps, be more clearly seen. According to Tyndall's "Heat as a Mode of Motion," German authorized edition, page 455 (Appleton's Edition, page 333), air saturated with moisture absorbs 90 times stronger than dry air, and in so doing, takes up 10 per cent. of the total heat. The absorption of dry air is, therefore, $\frac{1}{9}$ per cent. in a tube 2 feet 8 inches long, or in a tube 10 inches long, about $\frac{1}{37}$ per cent. or 0·037 per cent.; consequently:

| NAME. | Absorption in per cent. according to Tyndall. | Diathermacy in per cent. according to Tyndall. | Deviation which should be obtained by Magnus according to Tyndall. | Deviation according to Magnus. | Difference. |
|---|---|---|---|---|---|
| Vacuum, | 0· | 100· | 14·403 | 16·4 | +2· |
| Air, | 0·037 | 99·96 | 14·4 | 14·4 | 0· |
| Oxygen, | 0·037 | 99·96 | 14·4 | 14·4 | 0· |
| Hyrogen, | 0·037 | 99·96 | 14·4 | 13·9 | —0·5 |
| Carbonic Oxide, | 3·33 | 96·67 | 13·93 | 12·8 | —1·13 |
| Carbonic Acid, | 3·33 | 96·67 | 13·93 | 13·0 | —0·93 |
| Nitrous Oxide, | 13·13 | 86·87 | 12·51 | 12·0 | —0·51 |
| Marsh Gas, | 14·91 | 85·09 | 12·25 | 11·7 | —0·55 |
| Olefiant Gas, | 35·89 | 64·11 | 9·24 | 7·5 | —1·74 |
| Ammonia, | 44·22 | 55·78 | 8·03 | 6·3 | —1·73 |
| Moist Air, | 3·33 | 96·67 | 13·93 | 14·4 | +0·5 |

As may be seen, the deviation in the case of vacuum and saturated air, is, according to Tyndall, too great; whence it follows, that air with which Magnus compared all other gases, had, according to Tyndall, a much weaker absorption than was found by Magnus; while moist air, according to Tyndall again, absorbs much more than Magnus states. According to Tyndall's statement, there is almost no difference between air and vacuum; according to Magnus, on the other hand, there is none between dry and moist air.

Of these two results, that which concerns the absorption of moist air is of very great interest to meteorologists. While, therefore, the absorption of dry air did not come into further consideration, an interesting contest arose between the two experimenters upon the behavior of water vapor towards radiant heat.

After Magnus had pointed out the hygroscopic character of rock salt, Tyndall showed that when one reflector was placed within the experimental tube, the results remained the same; and when Magnus called Tyndall's attention to the impurity of London air, Tyndall immediately concluded to repeat the experiments in the pure atmosphere of the Isle of Wight. Still, again, moist air showed considerable absorption.

Later, in December, 1862, Tyndall read before the Royal Society a paper upon the absorption of moist air, in which were described experiments with *open* tubes, which confirmed his previous statements. The tube was filled alternately with dry and saturated air, and in every case the dry air showed itself by smaller, and the moist air by a greater absorption. Moreover, at the end of this paper, an experiment was mentioned, in which not only the rock salt plates, but also the tube itself were dispensed with. Between one source of heat, C,

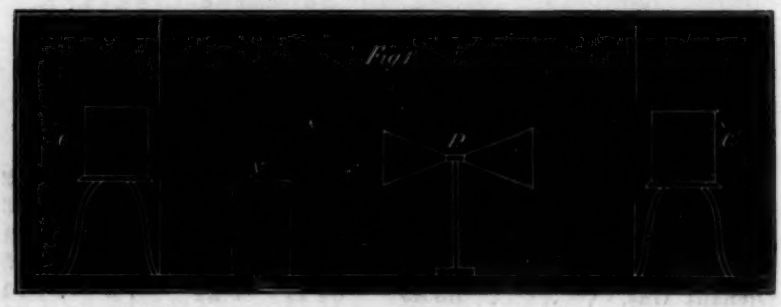


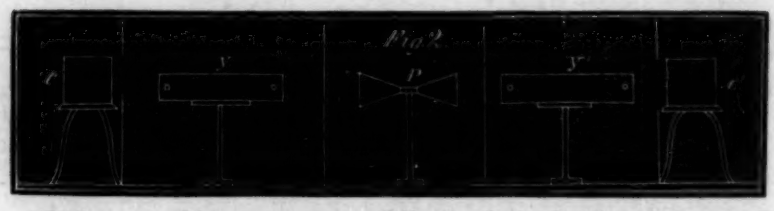
Fig. 1, and the thermo-pile, P, was placed a cylinder, Y, 3½ inches in diameter, which was filled alternately with calcium chloride, or with

fragments of rock crystal, which had been moistened with distilled water. Air was then forced through the cylinder between the cube and the thermo-pile. A part of the air of the laboratory, was, therefore, replaced, now by dry, and now by saturated air, and in every case Tyndall observed a deviation which confirmed his view. And not Tyndall alone, but also Prof. Wild, at Zurich, conducted experiments with open tubes; and in his case, a still greater absorption was observed than Tyndall gave. Moreover, Tyndall had the pleasure of showing to Magnus himself, his experiment with open tubes, and it is, therefore, entirely explicable that Tyndall should trust that "*the matter had been placed entirely out of the range of pure reflection.*"

2. But when we look more closely over the part which Magnus has had in this matter, our view is somewhat changed. In the first place, Magnus defends his apparatus against Tyndall's doubts in regard to it. He claims that his apparatus would not have been able to give results agreeing so closely with Tyndall's, if it had such grave faults as Tyndall affirms. On the contrary, he says, because in my case the gas is directly between the source of heat and the thermo-pile, without an intervening wall, Tyndall's experiments are the less to be relied upon.

In opposition to this, Tyndall says, that the direct contact of the source of heat and the gas must induce currents which would influence the result; and that in his own experiments the presence of the thermo-pile in the experimental tube caused a disturbance. The first objection is emphasized by Wild, who says that he was able to obtain no results, whatever, according to Magnus' method. Magnus answers Wild by saying that the latter employed a metallic tube, and consequently a good conductor, instead of a glass one, which he himself used. Still further he says, in the case of his own experiments, the disturbing currents were not there, for when he placed a rock salt plate so as to divide his tube into two equal parts, and then, after exhausting the upper part, experimented only with the lower half of the tube, everything was just as before. As to the disturbance which arose when the thermo-pile was placed inside the tube, Tyndall maintains this on the ground of experiments, in which only half of the pile was in the tube, and the other half was in contact with the outside air, which, however, is quite another thing than when the whole pile is placed within the experimental tube.

After Magnus, during his stay in London, had seen Tyndall's experiments, those with open tubes appeared to him to deserve the greatest confidence, and he concluded to repeat them on his return home. But, to his great astonishment, he always obtained opposite results. The blowing of moist air always manifested itself by a warming of the pile. The cause of this did not long remain unknown. The air blown through the open tube reached the pile itself, the water vapor was condensed, and heat was set free. Magnus, therefore, naturally supposed that Tyndall had made a mistake in the direction of the deviation; but not long after, Wild published his splendid investigations, which unequivocally confirmed the correctness of Tyndall's views. Magnus was at a loss to account for his error, and concluded, therefore, to repeat Wild's experiments with entirely similar apparatus. In so doing, he found that in his earlier experiments, the thermo-pile had stood too close to the experimental tube, for now the air failed to reach the pile, and he obtained the same deviation as Tyndall and Wild.



Wild arranged his apparatus as follows: On both sides of the pile, P, Fig. 2, were placed brass tubes Y and Y,′ 60 centimeters long, which again were flanked by the Leslie's cubes, C and C,′ which served as sources of heat. When now the air of one tube was replaced by moister, and that of the other by dryer air, there resulted in every case a considerable deviation of the needle. On repeating this experiment, however, Magnus soon observed that even when moist air was blown through both tubes, a deviation of the needle resulted, which was increased when one tube was blackened and the other polished. Still farther, when both tubes were lined with velvet, and the air blown through, the direction of the deviation was changed, the moister air showing the greater warming of the pile.

After reflecting on the cause of these phenomena, Magnus showed in the plainest manner possible, that water is always percipitated on the inner wall of the tube even from air not saturated. This *vapor*

*hesion*, as Magnus calls it, takes place when the temperature of the tube is about 12° C. higher than that of the air.

The explanation of the whole matter, therefore, is as follows: The heat reaches the pile not by direct radiation, but by repeated reflections from the inner wall of the tube. In the case of an open tube, this inner wall is always covered with more or less water from the air of the laboratory, which through absorption diminishes reflection. If now moister air is blown into one tube, still more water is deposited, and the reflection is still more diminished, while the blowing of dry air into the other tube evaporates in great measure the water layer, and consequently the reflection is increased. The observed deviation of the needle arises, therefore, not from the absorption of water vapor, but from the absorption of water itself.

This explanation of Tyndall's observations is so natural and satisfactory that no one is astonished to see Magnus at the conclusion of his paper express the conviction that if Tyndall and Wild would repeat his experiments they would no longer maintain the great absorption of water vapor.*

Let us not forget still further that Magnus did not pass by Tyndall's experiment in the open air, Fig. 1. He repeated this in the following manner: Four glass tubes about 66 centimeters long and closed at one end were placed horizontally side by side between the thermo-pile and the cube. Each of these tubes had 40 small holes through its upper side and the open ends were joined to a cross tube, which was connected with a bellows. When the bellows were in action, therefore, a number of fine currents of air were obtained which arose freely between the source of heat and the pile. When now air, saturated with water vapor and air quite dry, were alternately forced through the system of tubes, no change in the heating of the pile was to be observed, while on the other hand, carbonic acid, which according to Tyndall, absorbs just as much radiation as water vapor, occasioned in every case a noticeable cooling.

It is evident now, I think, in view of Magnus' experiments upon vaporhesion, that experiments with tubes, be they open or closed,

* And yet Tyndall (Radiant Heat, Appleton's Edition, p. 394) has shown by using a large experimental tube, and sending through it by means of a rock salt lens, a converging beam of heat, which consequently was not at all reflected from the inner wall of the tube, that the same results substantially were obtained as when a smaller tube was used, and most of the heat which reached the pile was reflected from its sides.—Trans.

deserve no confidence, and that Tyndall's single experiment in the open air is outweighed by Magnus' experiment of the same kind with negative result. I do not hesitate, therefore, to affirm that there is to-day no firm ground for accepting the absorption of water vapor as an incontrovertible fact.

3. It has been my wish for some time to arrive at greater certainty in reference to this important question, but only at the present moment have I found a favorable opportunity. I therefore concluded to begin the experiments at once. It was clear to me from what had previously been done in this field, that I could only employ experiments in the open air, and those too without the protecting covering with which Tyndall surrounded his apparatus.* I suspected that in the case of Tyndall's experiments, the current of dry or moist air, as the case may be, had been reflected and thrown against the reflector of the thermo-pile, in which event the same change of reflection must result as in the case of experiments with tubes. I concluded, therefore, to repeat Tyndall's experiment (Fig. 1) with a cylinder of the same size, Y, but without the covering, which might occasion currents within, as much as it kept them off from without.

To a very sensitive Wiedemann's reflecting galvanometer, which had already on several occasions† done me good service, and was rendered completely astatic by an auxiliary magnet. I connected a common Melloni thermo-pile, such as Ruhmkorff furnishes. The pile was fitted with two reflectors and on the right and left two Leslie's cubes were arranged in such a way that the needle showed no deviation. The telescope and scale were at a distance of 3650 millimeters. The arrangement was quite like Wild's (Fig. 2), but instead of the two tubes Y and Y′, there were two cylinders similar to the one which Tyndall used. One cylinder I filled with calcium chloride, and the other with bits of clean quartz which had been moistened with distilled water. When the air was forced through the cylinders, a current of dry air arose on the left, and of moist on the right, and the influence of these on the heat radiation could readily be observed This experiment was repeated many times, and although the two sources of heat, each by itself, occasioned a deviation of more than 500 scale divisions, I have never been able to observe the slightest

---

* Phil. Transactions, 1863.

† Maandblad van Natuurweten Schappen, Amsterdam, 1872 and 1873.

movement of the mirror when air was forced through the cylinders. And yet the thermo-pile was sensitive enough to show a distinct cooling when carbonic acid was forced through the calcium chloride cylinder. I also obtained quite a deviation when the second cylinder only was employed which was filled successively with bits of quartz which had been moistened with the following liquids: alcohol, methyl alcohol, sulphuric ether, acetic ether, bisulphide of carbon, and benzol.

The results of these experiments are arranged here in the same manner as Tyndall* gives them:

TABLE I.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Hydrogen, | unnoticeable. | 0· |
| Carbonic Acid, | 6· | 1·2 |
| Bisulphide Carbon, | 8· | 1·6 |
| Illuminating Gas, | 17·5 | 3·5 |
| Benzol, | 20· | 4· |
| Methyl Alcohol, | 36· | 7·2 |
| Alcohol, | 45· | 9· |
| Sulphuric Ether, | 84· | 16·8 |
| Acetic Ether, | 120· | 24· |
| Total, | 500· | 100· |

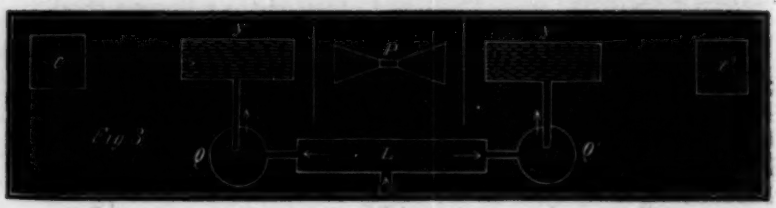
The series of vapors is exactly the same that Tyndall found. Moreover, the result was the same when the cylinder containing the liquids was placed on the right instead of the left of the pile. In general, personal equation and anomaly are entirely absent in these experiments, and anyone can easily repeat them with the same simple apparatus. The experiments were performed at different times in the day, and under different circumstances as to temperature. Finally I must add that in these experiments the very purest possible liquids were not employed, as was the case subsequently.

Although there were no disturbing influences at work, I could not perceive with the utmost straining of the attention, any absorptive action in moist air, and so I came to the same result as Magnus. Only two possibilities remained: either in Tyndall's experiments the protecting covering was the cause of the deviation, or my thermo-pile was not sensitive enough to show the action of water vapor.

In order to decide between these two possibilities, I undertook an

* *Philosophical Magazine*, 1864, vol. 28.

experiment with an ascending current of air of greater length. For this purpose I had prepared two metallic boxes, 25 centimeters long, 9 centimeters broad, and 5 centimeters high, closed on all sides, but fitted on one side with a tube and on the top with numerous small holes. These boxes replaced the tubes Y and Y′, (Fig. 2). The two cylinders remained respectively filled with calcium chloride and moistened quartz fragments, but were closed above with a perforated cork, through which passed a glass tube, which was connected with the side of the box by a bit of rubber tubing. The arrangement of the ap-



paratus is shown in horizontal projection in Fig. 8, in which C and C′ are Leslie's cubes, P, the thermo-pile, Y and Y′ the two boxes, Q and Q′ the cylinders, and L the tube by which the cylinder was connected with a bellows. With this arrangement, as will be seen, it was possible to obtain from one box a current of dry air, and from the other a current of moist air, which, if water vapor caused any absorption, would destroy the heat equilibrium of the thermo-pile.

On performing this experiment, I could with the greatest care observe a slight deviation of the needle. There was therefore actually an absorption in water vapor, and for Tyndall's result, the superiority of his thermo-pile was to be thanked. I could estimate the absorption at not more than $\frac{1}{2}$ per cent. But the deviation of the needle was insufficient for me to ascertain the matter with certainty, and so I placed the two boxes by the side of one another on the same side of the thermopile, and thus, as Tyndall did, obtained a column of moist and dry air alternately. By this means the ascending air current became 50 centimeters long. There now seemed no chance for mistake. Every time that the moist air arose, a deviation of 1 millimeter resulted in favor of the compensating source of heat, and on the employment of dry air a deviation of 3 millimeters in favor of the other cube. The total deviation when one source of heat was shut off was 294 millimeters. There was, therefore, an absorption of

1·7 per cent. On the same evening I obtained with illuminating gas and alcohol vapor the following results:

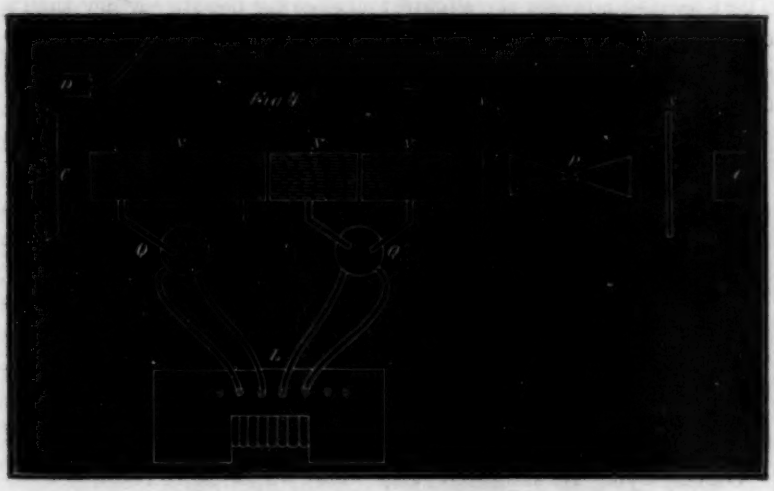
TABLE II.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Moist Air, . . . | 4·5 | 1·6 |
| Illuminating Gas, . . | 11·6 | 3·6 |
| Alcohol, . . . | 49· | 16·7 |
| Total, . . . | 294· | 100· |

The temperature of the room was 9° centigrade. On a subsequent day at the same temperature I obtained the following results:

TABLE III.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Moist Air, . . . | 4· | 1·7 |
| Bisulphide Carbon, . . | 5· | 2·1 |
| Alcohol, . . . . | 40·8 | 17· |
| Sulphuric Ether, . . | 43·5 | 18· |
| Methyl Alcohol, . . | 43· | 18· |
| Formic Ether, . . . | 53· | 22·1 |
| Acetic Ether, . . . | 63·5 | 26·5 |
| Total, . . . . | 240· | 100· |



For further investigations I increased the length of the ascending air current to one meter, employing for that purpose the apparatus whose horizontal projection is given in Fig. 4. Y, Y are the boxes

already described, each 25 centimeters long. Y′ is another box of the same kind, but 50 centimeters long, and with its top filled with small holes. Q and Q′ are the two well known cylinders which were now always filled with the same material, that is, either with calcium chloride or with moistened fragments of quartz. The cork of each was fitted with two tubes, which, by rubber tubing, were connected with Y and Y′. Two tubes were also fastened into the under part of the cylinders by which the whole arrangement was connected with the acoustical wind chest L, which now took the place of the common bellows. When, therefore, the corresponding keys of the wind chest were pressed down, a four-fold current of air issued into the boxes Y and Y′, expanded in them, and finally arose through the small holes in their upper surface, between the thermo-pile and the source of heat.

But now the boiling water did not furnish sufficient heat, and so in place of the Leslie's cube I employed a copper plate, C, covered with lampblack, and heated from behind by a Bunsen burner. To regulate the flow of gas, the apparatus D, which was invented by Cavaille-Col., and is attached by Konig to his syren, was placed in the gas connections. (See *Catalogue d'Instruments d'Acoustique.*) There seemed now not the slightest chance for doubt. Every time a current of dry air displaced the moist air of the laboratory there resulted a deviation in favor of the heated copper plate, as the following observation shows:

DRY AIR.

| Scale Reading Without Blowing. | With Blowing. | Deviation. |
|---|---|---|
| 27 | 32 | 5 |
| 28 | 35 | 7 |
| 29 | 35 | 6 |
| 30 | 35 | 5 |
| 31 | 36 | 5 |
| 30 | 35 | 5 |
| 29 | 35 | 6 |
| From the copper plate alone, . . . | | 322 |

On employing air saturated with water vapor there resulted a deviation of 1 millimeter, always in favor of the compensating Leslie's cube. This was shown also in the plainest manner possible by the change in the direction of the needle.

On the whole I obtained on this evening the following results:

TABLE IV. TEMPERATURE 9° C.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, . . | 6·5 | 2· |
| Alcohol, . . . | 75· | 23·3 |
| Total, . . . | 332· | 100· |

On the following evening I obtained the following numbers:

TABLE V. TEMPERATURE 7·5° C.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, . . . | 7· | 2· |
| Bisulphide Carbon, . . | 17· | 5· |
| Sulphuric Ether, . . | 67· | 19·7 |
| Alcohol, . . . . | 71· | 21· |
| Methyl Alcohol, . . . | 78· | 23· |
| Formic Ether, . . . | 79· | 23·2 |
| Acetic Ether, . . . | 92· | 27· |
| Total, . . . | 340· | 100· |

It is readily seen that the agreement is better, as might be supposed in such difficult experiments. I doubt not that it can be carried still closer, but my eye was chiefly directed to the behavior of water vapor.

From table V, it is clear that the greater length of the absorbing layer increases the absorption, although not in the same proportion, as was the case in Tyndall's experiments. I regard it, however, as certain that as far as concerns water vapor my experiments cannot be in error more than $\frac{1}{2}$ per cent.

I was curious to know whether the behavior of water vapor towards radiant heat was influenced in any great degree by the temperature of the room. For the purpose of deciding this I made a number of experiments in a room heated about 11° C. higher than before. The following are some of the results:

| After blowing. Dry Air. | Starting point on Scale. | After blowing. Moist air. | Deviation. |
|---|---|---|---|
| 21· | 16· | 9· | 12· |
| 22· | 16· | 9·5 | 12·5 |
| 21·5 | 16· | 9· | 12·5 |
| 21·5 | 16· | 8·5 | 13· |
| From the copper plate alone, . . . . | | | 535· |

TABLE VI.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, . . . | 12·5 | 2·3 |
| Sulphurous Acid, . . | 124· | 25· |
| Alcohol, . . . . | 149· | 28· |
| Total, . . . | 535· | 100· |

In reality an increased absorption resulted, but not in the proportion that I expected.

Still there is no doubt about the correctness of these observations, for a week afterwards I obtained the following numbers at 18° C.:

TABLE VII.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, . . . | 9·5 | 2·2 |
| Alcohol, . . . . | 110· | 36· |
| Total, . . . | 420· | 100· |

At the same higher temperature I made experiments with the two Leslie's cubes and the two boxes Y, whose complete length was 50 centimeters, that is with the same apparatus, as in the case of Tables II and III, and obtained the following results:

TABLE VIII.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, . . . | 3·5 | 1· |
| Bisulphide of Carbon, . | 5· | 2·5 |
| Alcohol, . . . . | 38· | 19· |
| Methyl Alcohol, . . . | 56· | 28· |
| Sulphuric Ether, . . | 56·5 | 28·2 |
| Acetic Ether, . . . | 75· | 37·6 |
| Total, . . . | 200· | 100· |

It appeared to me not unimportant to try likewise some experiments with another source of heat. For this purpose I employed again the apparatus represented in Fig. 4, in which the ascending air current was 1 meter long:

TABLE IX. TEMPERATURE 14° C.

With a common gas lamp, circular burner, and glass chimney.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, . . . | 2· | 0·4 |
| Alcohol, . . . . | 46·5 | 9·7 |
| Total, . . . | 480· | 100· |

TABLE X. TEMPERATURE 14° C.

With a plate of unglazed brick, heated from behind by a Bunsen burner.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, | 7· | 2·3 |
| Alcohol, | 78· | 26· |
| Sulphuric Ether, | 83· | 27·5 |
| Formic Ether, | 86· | 28·6 |
| Acetic Ether, | 98· | 32·6 |
| Methyl Alcohol, | 111· | 37· |
| Total, | 300· | 100· |

TABLE XI. TEMPERATURE 14° C.

With a four tube Bunsen burner, blue light, scarcely visible.

| Name. | Deviation. | Absorption. |
|---|---|---|
| Water vapor, | unnoticeable. | 0· |
| Alcohol, | 16· | 6· |
| Total, | 262· | 100· |

It is evident from the tables that with different sources of heat the series of vapors is not the same. Tyndall found the same thing to be true. The series is as follows:

TABLE XII.

| Leslie's Cube. | Heated Copper Plates. | Heated Brick. |
|---|---|---|
| Water vapor, | Water vapor, | Water vapor. |
| Bisulphide of Carbon, | Bisulphide of Carbon, | Bisulph. Carbon. |
| Alcohol, | Sulphuric Ether, | Alcohol. |
| Methyl Alcohol, | Alcohol, | Sulphuric Ether. |
| Sulphuric Ether, | Methyl Alcohol, | Formic Ether. |
| Formic Ether, | Formic Ether, | Acetic Ether. |
| Acetic Ether, | Acetic Ether, | Methyl Alcohol. |

Especially worthy of note is the behavior of the vapor of methyl alcohol, which in the case of the heated brick suddenly takes the highest rank in the series.

In order to present a better view of the subject, I give again here the results which I have obtained upon the absorption of water vapor together with those upon alcohol vapor.

TABLE XIII.

Influence of the length of the ascending air current.

| Name. | Air Column of 9 cent. | 50 cent. | 100 cent. |
|---|---|---|---|
| Water vapor, | imperceptible. | 1·6 | 2· |
| Alcohol, | 9· | 17· | 21· |

TABLE XIV.

Influence of the kind of radiation. Apparatus, Fig. 4. Temperature 14° C.

| Name. | Leslie's cube. | Heated Cop. plate. | Heated brick. | Gas flame. | Bunsen burner. |
|---|---|---|---|---|---|
| Water vapor, . | 3·* | 2·2 | 2·3 | 0·4 | imperceptible. |
| Alcohol, . . | 27· | 28· | 26· | 9·7 | 6· |

When we look back over the tables given above, the strife between Tyndall and Magnus appears to have been a very natural one. Tyndall overrated the absorption of water vapor, on account of vaporhesion; while Magnus infinitely underrated it on account of the shortness of his experimental tube. Magnus used in his experiments a tube 26 centimeters long. If we place the absorption in this at ½ per cent., this would give a deviation of only 0·08 of a scale division, in case the total deviation was 16·4 scale divisions. Magnus obtained only 0·1 of a scale division.

If we look at Table XIII, we see substantiated for vapors what has long been known in the case of solid and liquid bodies, that each following layer lets through more proportionally than the preceding one. Accordingly I believe that 100 meters of common air are far from being in condition to occasion the result which Tyndall expects from 10 feet, that is that 10 per cent. of the radiation which it receives is absorbed.

Still no one will call in question the value of Tyndall's splendid work, or of his speculations upon the great interest which attaches itself to the behavior of water vapor, of which he was the discoverer.

Utrecht, Feb., 1875.

---

**Transformation of Lead to Galena.**—Mr. Peter Spence, F. C. S., etc., exhibited at the Literary and Philosophical Society of Manchester, Nov. 2, 1875, a piece of 2 to 3-inch lead pipe in which the metal had been entirely transformed into galena, the crystallization being visible through the whole of the specimen. The pipe had been used for the conveyance of gas ammoniacal water, and was sunk under ground. A considerable leak of gas-water having occurred, a constant atmosphere of sulphide of ammonium would surround the pipe, and this seems to have been the cause of the conversion of the lead into sulphide, as only that part of the pipe which was in the vicinity of the leak was found to be transformed.

---

* These two numbers were obtained by a removal of the scale to 7·5 meters instead of 3650 millimeters, as in the case of the former experiments.

# PHENOMENA OF INDUCTION.

By Professor EDWIN J. HOUSTON.

The publicity given by notices in several newspapers within the past few weeks, of an alleged discovery of a new force by Mr. T. A. Edison, of Newark, N.J., which has been styled by him "Etheric Force," and the manifest general interest in these notices, lead me to present the following communication for the pages of the JOURNAL. In the JOURNAL OF THE FRANKLIN INSTITUTE for June, 1871, will be found a published description of some experiments which I made shortly prior to the date of publication, and which bear, both in method and results, a partial resemblance to those by Mr. Edison.

The experiments alluded to were made with a Ruhmkorff induction coil, capable of throwing the induced spark six inches in free air. I found that by connecting one of the poles of the secondary coil with a gas pipe by means of a good conducting wire, and the other pole by similar means, either with a large insulated conductor or with a semi-insulated conductor, as for example, by allowing the wire to rest on a dry lecture table, that the volume or quantity of the spark was greatly increased, and at the same time the characteristic whitening of the condensed spark produced. These results I attributed entirely to a condensation of the spark by connection with extended surfaces, similar to the condensation produced by the introduction of a Leyden battery into the circuit.

During the progress of the experiments the following facts were noted, which bear upon the observations of Mr. Edison. While the interrupter of the coil was in operation, making and breaking contact with the battery, sparks could be drawn from any metallic objects in the neighborhood of the coil, and, indeed, in adjoining rooms. For example, by holding a small metallic object in the hands, sparks were drawn, in an adjoining room, from a large pneumatic trough, in connection by soldered joints with the water-pipes of the building. Similar sparks were drawn from a half-horse power engine, also in metallic connection with the water-pipes, and from the steam boiler in the chemical laboratory on the floor below. A person standing on the floor could draw sparks from any of the gas pipes in the adjoining rooms by holding a knife blade to the pipes or burners. These

results I of course attributed to the action of the induced electricity from the coil, and published a note of them merely as a new experiment with the induction coil. On first hearing of the alleged discovery of the "Etheric Force" by Mr. Edison, I was led to think it probable that the phenomena observed by him were similar to those noticed by me in 1871, but from the brief descriptions published in the newspapers, was unwilling to make a public note of my belief. In the *N. Y. Tribune*, of December 9, however, Dr. Beard, of New York, has published a fuller account of the manner in which the experiments were conducted, and as far as I can gather they are of a similar nature to mine, and I feel warranted in believing that they can all find a satisfactory explanation by the presence of *induced electrical currents*, without the intervention of any new force whatever.

Immediately on reading the first published account of Mr. Edison's experiments, I repeated my original experiments in connection with my friend, Professor Elihu Thomson, of Philadelphia.

I append a brief description of our experiments. The induction coil already mentioned was worked by means of an electro-poin battery of ten cells coupled for an intensity of ten. The elements of each cell consist of a single plate of zinc placed between two plates of carbon. The available surface in each cell is about three by six inches. One pole of the battery was placed in metallic connection with a gas pipe and the other in similar connection with a large insulated conductor. On working the interrupting break-piece, a torrent of characteristic white sparks of condensed electricity passed between the platinum points of the coil. Under these circumstances, that is, while the discharges were occurring between the points, sparks could be drawn from all metallic objects in the same room with the coil, or in adjoining rooms. The sparks were especially noticeable when metallic objects were approached to the gas or water pipes of the building, or to metallic surfaces in connection therewith, as in the case of the pneumatic trough, steam engines, and boiler before mentioned. As already implied, actual contact between the gas or water pipes and one of the wires leading from the coil, was unnecessary, as distinct sparks were afforded by a stove in the same room, and from another in an adjoining room.

In order to test the suspected similarity between these sparks and those described by Mr. Edison, we submitted them to the tests pro-

posed by him. We made a number of experiments and obtained the following general results, viz.:

*First.* The gold leaves of a delicate electroscope did not diverge on being brought into contact with metallic objects yielding the sparks, although in every case the sparks could be seen at the point of contact.

*Second.* The needle of a delicate astatic galvanometer was not sensibly deflected by the sparks, on an apparent current being caused to traverse the coils of the instrument.

*Third.* A small shred of cotton wool was not sensibly attracted or repelled by objects from which the spark might be obtained.

*Fourth.* The so-called retro-action of the spark was distinctly observed. On looping a wire back on itself, a decided spark was seen at the point of contact made by the end of the wire with any portion of the wire itself.

All the above results are in strict accordance with the known laws of electricity, as will appear hereafter.

To still further compare these results with those obtained by Mr. Edison, we dispensed with the use of the induction coil, and employed an apparatus similar to that described by him, viz.: An electro-magnet in connection with the battery already mentioned, the current of which was rendered intermittent by means of an ordinary interrupter. With this arrangement, a wire in contact with the core of the magnet yielded sparks having all the properties described by Mr. Edison.

From a careful reading of the published accounts of Mr. Edison and Dr. Beard, it appears that the alleged discovery of a new force is based on their failure to obtain from the sparks, indications of electrical charges or currents; or in other words, in the apparent absence of electric polarity. All the effects noticed, however, are readily explainable by reference to the presence of an instantaneous outgoing current, immediately followed by an incoming one, with the complete re-establishment of electrical equilibrium. When we bear in mind the enormous velocity of electrical currents of this character, probably some hundred thousand miles per second, we can readily understand that the flow and reversion of the current would take place in an exceedingly small fraction of a second; a space of time insufficient, were the current merely direct, to produce any decided divergence of the leaves of the electroscope or the needle of the galvanometer. *The presence of the inverse current, immediately following the direct*

*current, would absolutely and necessarily prevent the exhibition of electrical polarity as exhibited in the motion of the electroscopes, galvanometers, and of similar instruments.*

It is doubtless due to the fact that the direct and inverse currents are opposite in their effects, and therefore produce instantaneous electrical equilibrium, that Mr. Edison failed to obtain the characteristic twitching of frogs' legs, or the discoloration of iodized paper; for, although these results would unquestionably follow an electric current in one direction, their presence would be masked by the opposite effects produced by the instantaneously following inverse current.

The possibility of the existence of the direct and inverse currents, as above described, may be questioned; but when we bear in mind that the sparks can only be obtained by the interruption of the battery current, and that it is necessary to pass the battery current through a long coil of wire, conditions in every way favorable to the production of instantaneous induced or extra currents; the direct and the inverse currents follow as a matter of necessity; for the induced or extra currents in the coil of wire necessarily produce, in the core of the magnet and the metallic wire in connection therewith, an electrical current in one direction, instantaneously followed on the cessation of the induced or extra current; by a current in the opposite direction for the re-establishment of the electric equilibrium in the cores of the magnet.

It is a fact well known to all versed in electrical science that the induced current produced at the moment of making contact with the interrupter flows in the opposite direction to that produced on breaking the contact. This fact would in itself, exclusive of the above explanation, be sufficient to account for the production of inverse currents in the core of the magnet, when the interruption of the battery current was sufficiently rapid. Dr. Beard admits that the phenomena may be referred to a somewhat similar explanation, but the value he attaches to his supposition, may be judged from his subsequent adoption of the term "apolic force" as a preferable term to "etheric force."

It is matter of surprise to us that both Mr. Edison and Dr. Beard endeavored by careful insulation to eliminate in the apparatus employed by them the effects of induced electricity or induction, since it is a recognized fact in electrical science that the more perfect the insulation the more decided the effects of induction; of which, perhaps, no

better instance could be found than the care taken to thoroughly insulate the secondary coils in the induction on Ruhmkorff apparatus. In view of the above considerations, we feel warranted in the belief that all the phenomena noticed by Mr. Edison and Dr. Beard are explainable by the presence of inverse electrical currents of considerable quantity, but comparatively small intensity, instantaneously produced at the making or breaking of the battery circuit.

There was noticed during the progress of our experiments with the induction coil, the following curious phenomenon, which appears to us favorable to the explanations we have adduced. One of the poles of the coil was connected with a gas pipe, and the other with an insulated conductor of considerable surface in the room containing the Ruhmkorff core. This room is in connection by a telegraph wire with the chemical laboratory on the floor below, and with an earth circuited station, D, in another building, about five hundred feet distant in a direct line. On the interrupter of the coil being worked, a peculiar clicking sound was heard by both of us in the line wire in the chemical laboratory. The operator at D was requested to observe whether any unusual phenomena were noticed at his instrument. He at once telegraphed to us that a distinct "tinkling sound" was heard, which did not vary whether the ordinary battery current of the line was opened or closed. Since he did not know what to expect, his confirmation of our observation was very satisfactory. The production of the sound is probably referable to a rapid succession of molecular changes produced in the wire by the sudden reversion of its electrical states.

Central High School, Philadelphia, Dec. 11th, 1875.

NOTE BY THE EDITOR.—It will be observed that these results of Prof. Houston were produced by the use of unquestioned electricity, as obtained from the Ruhmkorff coil, and the fact of their exhibiting all the negative properties, as well as the apparent absence of polarity, which Mr. Edison appears to regard as the proof of the existence of the new force, goes to show that the assumption of a new force is simply gratuitous. The experiments made by Prof. Houston had for the source of electricity, a Ruhmkorff coil, but the reference in the original article of 1871, to a cylinder or plate machine, demonstrates that the source of electrical force, whether magneto-electric, frictional, or derived from a battery, was, in the opinion of Prof. Houston, immaterial. It follows that whatever there may be *remarkable* in the phenomena of so-called Etheric Force, was described by Prof. Houston, previous to *the discovery* of Mr. Edison.

# ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxx, page 427.]

In 1842, Zinin succeeded in converting nitrobenzol into aniline by the action of nascent hydrogen, and thus opened out an industrial region of unimagined extent. The era of the artificial dyes followed. It was soon perceived that many of these substances shared with indigotin the property of being decolorized by hydrogen, and thus zinc powder was introduced into calico-printing as a discharging agent, which, developing hydrogen in patterns where it is printed on, removes artificial coloring matters, *e. g.*, magenta.‡

A series of interesting observations showed, however, that the manner in which hydrogen is evolved is not without influence on hydrogenization. Whilst ammonium sulphide, and whilst acids under the influence of metals give up so much hydrogen to nitrobenzol as to form aniline, if other sources of hydrogen are employed the reaction is arrested half-way and intermediate products are generated. Herewith, therefore, nascent hydrogen escapes from our general consideration, and its technical application will be described in future parts of this report.

We return, therefore, to its applications as a source of heat and light. It has been briefly described in the section on oxygen how the oxyhydrogen blast was evolved from the experiments of Saron between 1780 to 1790, and how it was introduced in the manufacture of platinum in the middle of the present century by Deville and Debray. Since 1838§ Desbassains de Richemont found in hydrogen

---

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News*.

‡ The transformation of the colored salts of rosanilin into the colorless salts of leucanilin by means of zinc and hydrochloric acid was discovered by A. W. Hofmann in 1860.—*Proc. Roy. Soc.*, vol. xii, p. 2. The above application is due to Durand. See Schützenberger, "Traité des Matières Colorantes," vol. i, p. 491.

§ Karmarsch, "Geschichte der Technologie," 380.

mixed with air the means for the autogenous soldering of sheets of lead, and thus supplied the sulphuric acid manufacture with the fundamental condition of its growth, *i. e.*, permanent lead chambers of any desired magnitude. If, in places where coal-gas is readily procurable, this combustible is substituted for hydrogen in soldering lead many sulphuric acid chambers are not near gas-works, and in them hydrogen is still necessary for soldering. The same must be said on the application of hydrogen for the autogenous soldering of other metals and alloys, a process for which Winckler, in his convincing essay already quoted, predicts a great future. More recently, lead pans soldered in this manner nave been introduced in the manufacture of boracic acid in Italy. Numerous conflagrations, especially that of Canterbury Cathedral in 1871, and that of the Alexandra Palace on Muswell Hill in 1873, demonstrably due to the braziers full of fire used in soldering the leaden spouts, have lead, in England, to the proposal to solder leaden roofing and spouting, with hydrogen.

How far hydrogen is superior to other kinds of fuel appears from the following table. According to the experiments of Favre and Silbermann, 1 grm. of the following bodies, when burnt in water, gave the appended number of calories, *i. e.*, it raised, by 1°, the temperature of the given number of centigrams of water.*

| | |
|---|---|
| Hydrogen | 34·462 |
| Carbonic oxide | 2·403 |
| Oil of turpentine | 10·852 |
| Stearic acid | 9·716 |
| Alcohol | 7·814 |
| Marsh-gas | 13·063 |
| Wood charcoal (burnt to carbonic acid) | 8·080 |
| Ethylen | 11·858 |
| Ether | 9.028 |

The temperature of the flame does not, however, depend exclusively on the heat of combustion. The density of the burning body and the specific heat of the products of combustion must also be taken into account. Hence it comes that the temperature of the hydrogen flame in pure oxygen is about 6800°, in air about 2600°; the temperature of the flame of carbonic oxide in oxygen amounts to 7000°, in air about 3000°;† further according to calculation 1 vol. of hydrogen = 1 grm.

* A. Wurtz, "Dictionnaire de Chimie," vol. i, pp. 825, 82.

†Debray, "Sur la Production des Températures Elevées et sur la Fusion de la Platine." Lecons de Chimie en 1861, 65; Paris, 1862.

is capable of fusing 205 grms. of platinum, whilst the same volume of carbonic oxide can fuse 238 grms. of platinum (melting-point 2000°.) In practice, however, even under the most favorable conditions, as Deville and Debray determined in their researches on platinum, about half the heat is lost by conduction to the furnace and other surrounding matter, and the above authorities with 120 liters of hydrogen and 60 of oxygen succeeded in fusing only 1 kilo. of platinum instead of double the amount as calculated. Platinum can also be smelted and refined under similar circumstances with coal-gas. But for the more infusible metals of the platinum group, iridium, ruthenium, and their alloys, the hydrogen flame must be retained, which, if costlier than coal-gas, is cheaper than carbonic oxide.

In the use of gases as fuel the metal itself can be brought in contact with the flame, which is impracticable in case of carbon, and thus the great loss of heat is avoided which ensues when the crucible is heated from without. Their application renders it also possible to inspect the condition of the metal at any moment. In the metallurgy of the common metals these two advantages do not come into consideration. Carbon, moreover, is not only the cheapest but the most productive fuel,* and the application of hydrogen as a source of heat seems therefore limited to autogenous soldering and to the fusion of the most refractory platinum metals.

The property of platinum-black to ignite hydrogen, of which Dobereiner made a well-known and widely utilized application in his hydrogen lamp in 1823, has lost its practical importance owing to the discovery of friction matches.

The more intense and permanent was the interest which hydrogen created as a source of light.

As the luminous power depends on the temperature at which a solid ignited body is maintained the suggestion was near at hand to produce an intense light by means of this gas, in which an incombustible body was heated to whiteness. To this end the Scotch military engineer Drummond used in 1826 cylinders of caustic lime heated in the oxy-hydrogen flame. The Drummond light has been widely employed, not merely in geodetic measurements and in lighthouses, which the inventor had principally in view, but also for projections of microscopic objects and photographic images on glass, or drawings upon

*The calculated temperature of the flame of Carbon in oxygen is 10,000°, from which has to be deducted the unknown amount of heat which at this temperature is lost by dissociation. See Debray, *opus citat.*

gelatine for demonstration in lecture-halls,* for disolving views, and chromatropes. In the American civil war it was used in sieges to light up forts.† The English war department has tried it in barracks in large halls and courts, in which‡ it is said to have proved cheaper than coal-gas, whils the smallest characters could be read at a distance of 90 meters from the source of light.

Since lime partially loses its luminous power by continued use, platinum-wire, magnesia, and latterly zirconia, have been employed in its stead.§

The above-mentioned applications of the hydrogen lamps are, however, of a very limited nature. To utilize it on the large scale for street lighting, the simultaneous use of oxygen has been laid aside, and cheaper methods of preparation have been sought for. For this purpose advantage was taken of Felice Fontana's method of decomposing water by means of ignited iron and ignited carbon, as proposed in 1780.‖ On the latter scheme Donovan founded his industrial preparation of hydrogen gas in Dublin in 1830. His process has been repeatedly described with modifications, referring in part to the needful apparatus, and in part to the diminution of the proportion of carbonic oxide. The presence of this poisonous gas was at first justly urged as an argument against the use of the "water gas." Langlois found that the mixture obtained—on allowing steam to pass over iron retorts filled with red-hot coke in Kirkham's apparatus—had the tolerably constant composition of 58 to 60 per cent. of hydrogen, 19 to 26 carbonic oxide, and 15 to 20 carbonic acid.

(To be continued.)

---

**Carbonic Acid in Air collected by the Balloon "Le Zenith."** By G. Tissandier (*Compt. Rend.*, lxxx, 976–978). By means of a reversible aspirator, having a capacity of 22 liters, the air was drawn through tubes containing pumice stone saturated with potash solution. The carbonic acid was afterwards expelled by sulphuric acid, and measured over mercury. It was thus estimated that at an altitude of from 800 to 890 meters, 10,000 volumes of air contained 2·40 of carbonic acid; and at 1000 meters, contained 3·00 volumes. The difference between these numbers is not greater than in the results obtained at the surface of the earth.

---

* This Report, p. 14; also H. Vogel, *Ber. d. Chem. Gesell.*, iii., 901.

† Wagner, "Lehrbuch der Technologie." 9th edit., ii., p. 377.

‡ *Journal of Gas-lighting*, 1869.

§ See the work of Phillips, quoted above.

‖ *Mem. Soc. Ital.*, xv.

# ON NOCTILUCINE, THE PHOSPHORESCENT PRINCIPLE OF LUMINOUS ANIMALS.*

By Dr. T. L. Phipson, F.C.S.

*Member of the Chemical Society of Paris, and of the Royal Society of Medical and Natural Sciences of Brussels, etc.*

In reviewing the various phenomena of phosphorescence, which are so numerous, both in the mineral world and in organic nature, it is not very difficult to convince one's self that in the great majority of well-observed cases belonging to the former, the production of light can be directly referred to electrical action, or to electrical action resulting from chemical action, and the latter mostly from oxidation.

As examples of purely electric action, may be cited the light produced in the formation and cleavage of crystals; the sparkling of boracic acid when cooling after fusion; the light emitted by benzoic acid during its sublimation; the flash of light that accompanies the cleavage of a plate of mica, when one fragment is found to be electro-positive, and the other electro-negative, immediately after the operation; the light emitted when quartz pebbles are violently rubbed together, which is accompanied by an odor of ozone; the flickering scintillations observed when a mixture of sulphate of soda and sulphate of potash crystallizes, when arsenious acid crystallizes, when crystals of sugar or nitrate of uranium are broken, and a very great number of similar cases which it would be far too long to mention here. In fact, the more the phenomenon is observed, the more general it appears to be throughout nature.

As examples of electrical action following on chemical action, may be cited the luminosity of phosphorus, of potassium and sodium, of arsenic, sulphide of antimony, and a considerable number of cases where oxidation, or other chemical action is intense. I have referred to all these in another place.†

In the organic world, with one exception, the luminosity of animals and certain plants can be with tolerable certainty referred to the production of the principle which I have termed noctilucine. The

*Read before the British Association for the Advancement of Science, Bristol, 1875.

† "Phosphorescence; or the Emission of Light by Minerals, Plants and Animals." London, 1862.

one exception is when the production of light can be traced also, with the greatest probability to electrical action. This is evidently the case with the sparkling radiations which are occasionally seen round the flowers of the marygold and several other plants at a certain period of their growth, when the atmospheric conditions are favorable. The phenomenon is coincident with the rupture of the anthers and the ejection of the grains of pollen. We have other examples of a similar production of light resulting from the sudden rupture of plant tissue in dry weather.

Noctilucine is a peculiar organic principle, which appears to be very widely spread through nature. It is the cause of the light of the glow-worm, the scolopendra, the fireflies, the pholas, and numerous other luminous animals, both during life and for a certain time after death. The first allusion to the existence of this substance occurs in my note, "Sur la Matiere Phosphorescente de la Raie," published in the *Comptes Rendus* of the Paris Academy in 1860, where I have spoken of it as a peculiar organic matter, devoid of phosphorus, but shining in the dark like that element itself. It was found, by the most careful tests, to contain neither phosphorus nor phosphoric acid. It is again alluded to in my work on "Phosphorescence," published in London in 1862, (p. 103), and finally in my paper, "Sur la Noctilucine," in the *Comptes Rendus* of the Paris Academy for August 26, 1872, (p. 547). The same substance is noticed again, exactly one year later, (August 25, 1873), in the same publication by Professors Ch. Robin and M. Laboulene.

Noctilucine is not only the cause of the phosphorescence of dead fish and animal flesh of every kind, but it is secreted by living animals, such as the glow-worm, the scolopendra, the fireflies (*Elater*), the common earth worm, and by a very considerable number of others, amounting probably to many hundred distinct species, that are seen to shine in the dark. It appears to be produced also by certain living plants—*Agaricus*, *Rhizomorpha*, and *Euphorbia* (?)—and occasionally in the decomposition of vegetable matter (putrid fermentation of potatoes, etc).

At the ordinary temperature of summer in this climate, noctilucine is a fluid nitrogenous substance, slightly viscous or oily in appearance that can be mixed with water, but does not dissolve, though the watery liquid can be filtered; its specific gravity is slightly less than that of water; its color is white, when impure, yellowish white, and when decomposed becomes brown.

When recently extracted from a living or dead animal it invariably contains a certain quantity of water, and possesses a slight odor recalling that of caprylic acid; it is insoluble, or only slightly soluble, in alcohol and ether, but mixes with them and with glycerine. It is dissolved and easily decomposed by acids and alkalies, and when heated with potash it evolves ammonia.

Alcohol, ether, and especially mineral acids, extinguish its light very readily. When left for some days in contact with pure water, it enters into decomposition, and evolves after a time an ammoniacal odor of putrid cheese.

As long as it is moist, noctilucine absorbs oxygen and evolves carbonic acid; but, when left in the air, it dries up into thin, semi-transparent films, quite devoid of structure of any kind, and then resembles the substance called *mucine*, which has been obtained from garden snails and other Gasteropoda.

When recently obtained, noctilucine is highly phosphorescent, and this production of light is evidently due to oxidation in contact with the air. Numerous experiments leave me in no doubt of this. It will even shine in water when air is present in that liquid. As already stated, it is slightly soluble in water; at any rate, it mixes so intimately that the liquid, after filtration, is luminous in the dark when stirred, but as the oxidation of the noctilucine proceeds, the water becomes turbid or milky and ceases to shine; it soon after enters into decomposition, evolving first an odor of propylamine, and afterwards an odor of putrid cheese.

In oxygen gas, the light emitted by noctilucine is rather more vivid than in the air, but it is more brilliant still during a southwest wind that carries much ozone. The production of light ceases when oxidation is completed, but, when the slightest quantity of air adheres to it, noctilucine will shine for a little time in moist carbonic acid.

In the heat of summer, noctilucine occasionally gets separated from the bodies, living or dead, of various marine animals, in sufficient quantity to form a thin oily stratum on the surface of the water of stagnant pools or coves on the sea coast. This oily layer gives out light when stirred so that the air can come well in contact with it, the surface being completely oxidized and having ceased to shine. Near the pier at Dover, and at the back of the port at Ostend, I have seen many square yards of water covered with this film of noc-

tilucine in June and August; it contained few or no luminous animals, and in the evening shone when stirred. The same thin layer will form, in the course of twenty-four hours, on water in which noctilucine obtained from dead fish has been dissolved, or rather mixed; and I possess four observations of the same formation occurring upon urine. In all these cases light is emitted from the film whenever it is stirred so that it comes thoroughly in contact with the air; after repeated stirring when oxidation is completed, the light ceases to be seen.

According to some recent observations upon the fireflies of the West Indies, by Professor Charles Robin and Dr. Laboulene (*loc. cit.*) it appears very probable that noctilucine gives rise to uric acid, or urates of ammonia and soda, in its final decomposition, as these substances are invariably found in the phosphorescent organs. The characters of the luminous substance, as investigated by them in these exotic insects, correspond to those of the noctilucine extracted by me from fish, and from the glow-worm and scolopendra. These gentlemen have studied the anatomy of the luminous organs with almost as much care as Professor Paoli Panceri has studied these organs in polypes and other lower animals, in a series of remarkable papers read to the Royal Academy of Naples in 1872, and profusely illustrated.*

In phosphorescent animals noctilucine is secreted by a special organ, just as bile is secreted by the liver, and this luminous organ is as special in its character as is the electric organ of the *torpedo* or *gymnotus*. The substance is produced, and gives light, as fast as it is required. But noctilucine is also produced under certain conditions of temperature and moisture by dead animal matter, such as flesh, blood, and sometimes in urine. Whatever may be its origin, it always gives the same kind of light; the spectrum of this light really spreads from C to a little beyond F, when the phosphorescence is very vivid (as in the *Elaters* of the West Indies), but its brightest portion lies between the lines E and F, and in most cases this portion only is visible, and the light appears nearly monochromatic. It has no lines nor bands of absorption. As far as I have hitherto been able to examine it, noctilucine, whether extracted from dead fish,

*The researches of these distinguished physiologists have confirmed most completely my earlier conjectures as to the special character of the luminous organs of phosphorescent animals, even those lowest in the scale of animal life.